A HANDBOOK

OF

PHYSIO-THERAPY

BY

ALVAH M. STAFFORD, M.D.

Medical and Surgical Publishing Company
CHICAGO

This volume is dedicated to those chiropodists who, by ethical practice and studious application, are sincerely striving to place their profession upon a dignified and scientific basis.

CONTENTS

CHAPTER V

CHAPTER VI

CHAPTER VII

CHAPTER VIII

CHAPTER IX

CHAPTER X

CHAPTER XI

CHAPTER XII

CHAPTER XIII

CHAPTER XIV

CHAPTER XV

INTRODUCTION

Physio-therapy, as the name implies, is the use of physical measures in the treatment of disease and deformity. Under this heading is grouped all forms of electricity; heat; cold; all forms of radiant energy including x-ray; radium; ultra-violet ray; infra-red ray; visible light; exercises, mechanotherapy and hydrotherapy.

I shall consider these modalities with especial reference to their application in the practice of chiropody and purpose discussing them as simply as possible without neglecting essential technicalities. As a matter of fact the greatest source of failure and disappointment in the use of physical remedies in the past has been due to a lack of understanding as to the nature of the agents employed and their action. To obtain results with any remedy three things must be known, first, the character and properties of the remedy used. Second, its action upon living tissues. Third, the pathology or nature of the disease or deformity treated. Ignorance upon any of these three points will result in dissatisfaction, if not complete failure.

The practice of modern chiropody has progressed beyond the removal of excrescences of the foot and kindred ailments. Due to the organization of scientific bodies and the establishment of schools and clinics chiropody has made for itself a definite place in the healing art and is being considered, more and more, a logical adjunct or specialty of medicine.

If the chiropodist is to intelligently treat the host of local foot diseases and deformities he must of necessity possess additional remedial agents and methods than those hither-to used, as well as a comprehensive and scientific knowledge of their action and application.

Unfortunately the various physio-therapeutic measures have been exploited by the ignorant and unscrupulous in the past which has resulted in a wide-spread misapprehension as to their true

scientific worth. Within a very few years a great change has taken place, men of scientific attainment have devoted their energy and time to physio-therapeutic research resulting in a broader knowledge along this line. New conceptions have eliminated erroneous ideas and faulty technic with the result that the practice of physio-therapy now rests upon an acknowledged and scientific basis.

The diseases and deformities afflicting many veterans of the world war created a wide field for the application of physical modalities and the scientific knowledge gained in this way in the various hospitals since the war has been greater than that of many preceding years.

Physio-therapy is now included in the curriculum of several colleges and the American Medical Association has created a council of physio-therapy to supervise its study and practice as well as investigate the merits of appliances offered for sale.

It must not be thought that physio-therapy is a panacea for all ills, for it is not. As a matter of fact its application is not spectacular, nor its results, generally speaking, immediate and outstanding. Chiropodial cases requiring physical treatment are for the most part sub-acute or chronic in character and therefore it is quite evident that results will be slowly attained irrespective of the mode of treatment, but physio-therapy offers a broad field from which may be chosen agents of definite and proven action, which may be obtained in no other way. In other words, physio-therapy places additional tools in your work chest which are capable of producing results if scientifically used.

I trust that this handbook may be of help to all who read it and that it may lead to broader study and understanding along these lines. In its compilation I have endeavored to bring the subject matter up to date and in doing so have quoted freely from the works of the following authorities: Neiswanger; Massey; Snow; Titus; Sampson; Stewart; McKenzie; DeKraft; Geyser; Plank; Wyeth; Kellogg; Chesney; Cumberbatch; Eberhard and Clark, as well as the writings of many medical men in the medical press.

I desire to acknowledge the courtesy shown by appliance makers in furnishing the cuts used in illustrating this book.

A. M. STAFFORD, M. D.

New York City, March 1, 1928.

CHAPTER I

ELECTRIFICATION AND MAGNETISM

THEORY; DEFINITIONS; FORMS

What is electricity? We do not know, but we do know that a state known as electrification exists which is assumed to be due to an agent known as "electricity." Phenomena produced by electrical energy are capable of scientific demonstration as well as the effects obtained by the passage of electric currents through living tissues.

An **Atom** is the smallest particle of an element capable of entering into combination, as for example an atom of hydrogen (H), oxygen (O), or copper (Cu).

A **Molecule** is the smallest particle of matter capable of existing in a free state. It consists of two or more atoms in combination, as for example water (H^2O), sulphuric acid (H^2SO^4) and copper sulphate ($CuSO^4$).

An **Ion** (meaning to go or travel) is an atom or group of atoms bearing an electric charge. Those ions which carry a positive (+) charge of electricity are known as *protons*, those having a negative charge, (—) *electrons*.

Electron Theory. An atom contains a minute nucleus of positive electricity which contains most of the mass of the atom. Outside of this nucleus there are particles of negative electricity, called electrons, each having a mass of about 1/1800 of that of an atom of hydrogen. In its natural unelectrified condition a body has a certain number of electrons; when it has more than this normal number, the body is negatively electrified, and, when it has less than the normal number, it is positively electrified.

It seems probable that in a non-conductor most of the electrons are associated with or bound to atoms and possibly vibrate or rotate about the center of atoms, as planets rotate about the sun; but in conductors most of the electrons are dissociated from atoms and are capable of moving about freely, thus accounting for the flow of electricity in conductors.

All chemical elements are either positive or negative and it is because of this and the attraction of unlike kinds of electricity that we have chemical combinations.

How is electricity produced? Electricity or electrical energy is produced chemically in batteries by the action of various elements upon one another. These usually consist of an acidulated fluid or electrolyte in which is suspended two elements, zinc or copper in combination with the non-metal carbon being the most common arrangement. Dilute sulphuric acid is the common electrolyte. Dry batteries in which the liquid electrolyte is replaced by a solid or semi-solid element are also used. A single battery is usually known as a cell, or battery cell, while a group of cells is known as a battery.

Electricity is also produced mechanically by electric dynamos, generators and static machines. The former is the method used to furnish commercial electricity.

Forms of electricity. Electricity is grouped under two general headings. 1. Dynamic or flowing, current, or active electricity. 2. Static or electricity at rest, inactive; an accumulation within a substance which can be released by friction.

Dynamic Electricity	Alternating Currents	Faradic
		Sinusoidal Rapid
		Sinusoidal Rapid Surging
		High Frequency Currents
Static Electricity	Direct Currents	Galvanic
		Galvanic Interrupted
		Sinusoidal Slow
		Sinusoidal Slow Surging

How do we measure electricity?

A **Volt** is the unit of electrical pressure, that which moves electricity from place to place.

Voltage is electric pressure, as the pressure of the blood in the blood vessels. Potential, Tension and Electro-motive Force (E. M. F.) are synonymous terms.

Ampere is the electrical unit of volume or quantity.

Amperage is the strength of an electrical current.

A **Milliampere** is the medical unit of amperage and is 1/1000 of an ampere, which would be too large an amount of electricity to use in physio-therapy. Consequently the ampere is reduced 1,000 times and its administration reckoned in milliamperes.

The **Ohm** is the electrical unit of resistance.

Ohmage is the resistance or obstruction offered by a substance to the passage of an electrical current. If ohmage equalled voltage there would be no electric flow.

The **Watt** is the electrical unit of flow or rate at which electricity is used.

Wattage is amperage voltage. One ampere of current forced by ten volts will develop ten watts of electricity. A Kilowatt is 1,000 watts.

From the preceeding definitions it will be seen that there is a definite relation between voltage, amperage and resistance. A gain or loss to any one of these three factors is a gain or loss for one or both of the other factors.

Voltage taken by itself means nothing at all. The same is true of amperage. The two must be taken together or not at all, while their joint action will be influenced by the resistance.

In order to make the difference between voltage and amperage clearly understood let us compare electricity flowing through a wire to water flowing through a pipe. We will assume that we have a barrel of water, elevated several feet from the ground, through the lower side of which a pipe one inch in diameter projects at right angles. Due to the force of gravity the water will flow horizontally out of the pipe to a certain distance and then,

describing an arc, will fall to the ground. Again we will assume that a powerful force-pump is connected to the barrel containing the same amount of water and the pump put in action. Immediately a stream of water is discharged a much greater distance from the outlet of the pipe, depending upon the pressure exerted, and finally falls to the ground. The quantity of water in both instances is the same, the friction produced upon the inner surface of the pipe by the passage of the water remains the same; what then is the cause of the increased velocity and distance of projection? Pressure. The amount of water may be compared to *amperage*, the friction caused by the water flowing through the pipe to *resistance*, and the driving force of the pump to *voltage*.

Sampson uses a rifle bullet in drawing a similar comparison as follows: "Let us take a sheet of tin (a resistance) and bend it around a six-inch pine pole (another resistance). Now let us take a 22-calibre Flobert rifle, using a very small cartridge (¼ inch or so long) with a few grains of black powder in it. Let us step off some twenty steps, aim the rifle at the center of the tin and fire it. What happens? The bullet strikes the tin, dents it, and is deflected to one side, striking the dirt off some yards away. Now let us take the same bullet, or one of exactly the same size and weight, fit it into the end of a 22-calibre high power cartridge shaped like a beer bottle, some 2½ or 3 inches long and filled with high power smokeless powder, chamber this cartridge in a 22-caliber rifle built strong enough and chambered large enough to handle it and aim it at the center of the tin and fire it. What happens now? The bullet strikes the tin (the first resistance) tears through it, mushrooms into a wider diameter and tears on through the pole (the second and much higher resistance) and knocks off half a peck of splinters where it exists on the other side and continues on over into the next township.

"What made the difference in the behavior of the two bullets? Voltage, that's all. In electricity, for practical purposes voltage may be compared to the speed of a bullet and amperage to the mass of the bullet. In the illustration given, we used the same

mass each time, but the Flobert cartridge projected that mass at something like 340 feet per second and it did not have momentum enough to carry it through even the first slight resistance it met. In the second case the high powered rifle projected it at somewhere around 4,000 feet a second, and it had momentum enough to carry it not only through the first resistance, but also through the second and very much higher resistance immediately behind it."

Magnetism and Polarization. The nature of magnetism or magnetic force is not known, but we do know that such a force exists and that an intimate relation exists between electricity and magnetism. In fact it would appear that magnetism and electricity are but different manifestations of one and the same agent.

The earth is a great magnet as evidenced by the use of the compass, the needle of which points due north and south to the two magnetic poles of the earth. The end of the needle pointing to the north pole is known as the N. or positive pole and the other end as the S. or negative pole. At the equator, the north and south poles being equidistant, results in a neutralization of polar attraction and the needle points directly downward.

An iron ore called *lodestone* is found which has natural magnetic power. Artificial magnets may be made by rubbing a piece of iron or steel upon another magnet. Soft iron magnetizes faster than hard steel, but gives up its magnetic load much easier and quicker, consequently hard steel is used for permanent magnets while soft iron is used where a magnet is required to charge and discharge quickly.

The ends of a magnetized steel bar differ in the greatest degree as to their magnetic attraction. If the bar magnet be suspended at its exact centre by a silken cord, it will swing to a certain definite position and remain there as did the compass needle. One end, that called positive, or plus, will point to the north pole and the other called negative, or minus, will point to the south pole. If the magnet is turned to the reverse position and released, it will immediately swing back to its original position.

If the positive pole of a bar magnet is touched to the positive pole of another magnet a repelling force will be apparent, in fact sufficiently strong to force the two positive poles apart. On the other hand, if the positive pole of one magnet and the negative pole of the other magnet are brought together, a decided attraction will be noticed even before the two poles are in apposition and an attempt to separate them will be met with considerable resistance, depending upon the size and magnetic force of the magnets.

These simple experiments prove the truth of the law of magnets. *Like poles repel, unlike poles attract one another.* This law applies also to the poles of an electric battery, the distinctive action of the positive and negative poles being known as polar effect or *polarization.*

In a battery cell consisting of a glass jar, with a zinc and carbon plate suspended in a solution of sulphuric acid (electrolyte) the chemical action of the acid upon the plates will cause electrons to gather at the zinc plate and protons to gather at the carbon plate. A wire connected to the zinc plate will carry a positive electric charge while the one connected to the carbon plate will carry the opposite negative charge. If the terminals or ends of the two wires are brought together, an electrical circuit will be formed, with the current flowing from positive to negative. When the ends of the wires are brought in contact the current is *made* or *closed*, in other words "switched on"; when the contact points are separated the current is *broken* or *opened*, or in other words "switched off."

Magnetic field. The space surrounding a magnet is called a magnetic field, the extent of this depending upon the strength of the magnet, and substances coming within this field are magnetized by induction. The force of attraction or repulsion in a magnetic field varies in different parts of the field and decreases with an increased separation of the poles of the magnet and the body upon which the force acts.

Electro-magnet. When a soft iron bar is wound with several turns of insulated wire and the ends of the wire connected with

the positive and negative poles of a battery it will be seen that the iron bar has acquired the properties of a magnet and forcibly attracts particles of metal brought near its poles. But the instant the circuit or current is broken the iron loses its magnetic force and the metal particles fall away from the attracting poles of the magnet. This is known as an electro-magnet, because it is a magnet produced by electricity and has the property of inducing an electric current in bodies brought within its field. This principle is used in the construction of the Faradic battery, induction coils, transformers and other electrical devices.

Conductors and Non-conductors. A conductor is a material which readily permits the passage of an electrical current. All the metals are conductors of electricity. A solution is said to be an *electrolyte* when it will conduct electricity. Acids, bases and salts in aqueous solutions are good conductors and that is why a solution of common table salt is used to wet electrodes used in electro-therapeutic treatment.

Non-conductors or Insulators are those substances which do not permit the passage of electricity. Glass, porcelain, rubber, silk, cotton, dry paper, mica, dry wood, shellac, paraffine and sealing wax are the best insulators. Dry air is a non-conductor. Of the liquids oils, fats, alcohol and chloroform are non-conductors or more properly speaking non-electrolytes.

CHAPTER II

GALVANIC CURRENT

Definition; Production; Properties; Physiological Action; Therapeutics and Technic.

Definition.

The Galvanic, also known as the Direct; Constant; Continuous or Voltaic current, is one having a low voltage and fixed polarity, always flowing from the positive (+) pole or anode to the negative (—) pole or cathode in a smooth, unbroken impulse, unless interrupted or modified by manual or mechanical means, in which case it is known as the *interrupted* or galvanic sinusoidal. (Fig. 1.)

Fig. 1
Diagrammatic Tracing of Interrupted Galvanic Current.

The galvanic current has a genuine chemical action, due to its fixed polarity. The positive pole attracts negative ions which the negative pole has repelled, while the negative pole attracts positive ions which the positive pole has repelled; following the well known law that "likes repel while unlikes attract."

The positive pole is acid, the negative is alkaline. Their action is opposite in every way.

Production.

The Galvanic or Direct current may be produced by a battery or cell, wet or dry, or by a magneto, dynamo or generator.

The ordinary direct current furnished by commercial power and lighting companies in many sections and office buildings is a galvanic current and may be used direct from the street main after its strength and pressure is reduced by passing it through a rheostat and measuring its volume by a milliamperemeter.

Rheostats are constructed in various ways, their principle being the same, namely accurately applied resistance. (Figure 2.) A common form consists of a circular plate of graphite upon which

a lever with handle may be revolved from the centre, as a hand upon a clock. Another form is made of many concentric windings of

Fig. 2
Rheostat or Resistance Coil.

fine wire upon the same plane, much as a clock spring is coiled. In either case as the lever is slid around over the surface of the rheostat upon its axis, the resistance offered to the passage of the current by the graphite plate or wire coil is increased or decreased, depending upon the direction in which the lever is moved. As resistance influences voltage, so is the strength of the current raised or lowered.

A milliammeter or milliamperemeter is used to measure the volume, or milliamperage, of the current passing through the patient's circuit. (Figure 3.)

In addition to reducing the strength of the current by passing it through a resistance coil or rheostat, one or more incandescent lamps may be placed in series which will further reduce the voltage. A lamp or device is "in series" when all the current reaching the patient goes through it.

Caution. When the direct current is used from the street main, controlled by a rheostat, the polarity should always be checked before using. Connection is usually made to the street circuit outlet by a split-socket plug or connector. When a plug is pulled out

and the prongs reversed in inserting it, the polarity will necessarily be reversed. It is well to mark one prong of the plug so that it can always be inserted in the same manner. If after plugging in on the circuit the prongs are found to be reversed and the polarity changed, simply remove the plug and reverse the prongs.

The better type of galvanic outfits include a separate generator which furnishes the current delivered to the patient and is ground free. The use of current direct from the street main is hazardous practice.

In localities in which the alternating street current is furnished and a galvanic current is required for therapeutic purposes it will be necessary to generate a direct current by a motor-generator. This consists of a motor which is driven by the alternating street current and the power derived from this used to drive the direct current generator, which gives the desired galvanic current. In many electrical outfits such a generating set is built into the machine.

Properties.

All galvanic currents have a fixed polarity, one pole or terminal being positive (the anode) and the other negative (the cathode). The flow of the galvanic current is from the positive to the negative. The former attracts negative ions (electrons) which the negative has repelled; likewise the negative pole attracts the positive ions (protons) which the positive pole has repelled. Again demonstrating the law that likes repel and unlikes attract.

The positive pole is *acid* and gives off hydrogen, the negative pole *alkaline* and gives off oxygen.

Since polarity is so important, it is necessary that we have some simple method of testing same. With moist blue litmus paper we may obtain the characteristic red acid reaction when touched by the positive pole or anode; while the negative pole or cathode will turn red litmus paper blue, the characteristic alkaline reaction.

Another test is made by inserting the two poles in water (H^2O) and turning on 20 to 30 milliamperes of current. Bubbles gather

at each pole, but as there are twice as many hydrogen atoms as there are oxygen, and as the positive hydrogen is repelled to the negative pole, there will be twice as many bubbles upon it.

Another test is made by observing the swing of the needle of the milliammeter. When the needle swings to the left hand binding post it means that the left hand post is the positive pole. If it swings to the right the right hand post is the positive pole, for the galvanic current always flows from plus to minus. If the face of the milliammeter has a one way scale then, of course, the meter will not register unless the polarity is correct. If the needle does not register or tries to get back of zero mark, you may be sure the poles are reversed.

Ionization. Acids, bases and salts break up in watery solutions. This is called ionization. This breaking up of molecules or atoms into ions takes place as the solute (acid, base or salt) is dissolved in the watery solution and is not dependent upon the action of an electric current from an outside source. When a solution ionizes, some of the ions are electro-positive (protons) and some are electro-negative (electrons) and as a polarity current passes through the solution the ions which carry a positive charge are attracted to the cathode, and because they travel to the cathode, are called cations. At the same time the ions which carry a negative charge are attracted to the positive pole, or anode, and are called anions.

Oxygen being an anion, travels to the positive pole or anode in the form of the hydroxyl ion OH and after the current has passed for some time between the two electrodes, the tissues about the anode will become acid in reaction, due to the formation of hydrochloric acid. Hydrogen being a cation, is attracted to the cathode and the tissues about the negative electrode become alkaline in reaction due to the formation of sodium hydroxide or caustic soda.

This principle of ionization is used in medicine to force drugs into the tissues and is known as Ionic Medication, Phoresis or Ionization. It is also used in the destruction of abnormal growths,

etc., by the method known as Electrolysis. Both of these methods will be considered later.

Physiological Action.

Local Galvanism. As previously indicated, the two poles of the galvanic current have a distinct and separate action and their individual application and position depends upon the nature of the pathological condition under treatment and the results to be obtained.

Local application of the anode has an anodyne or sedative

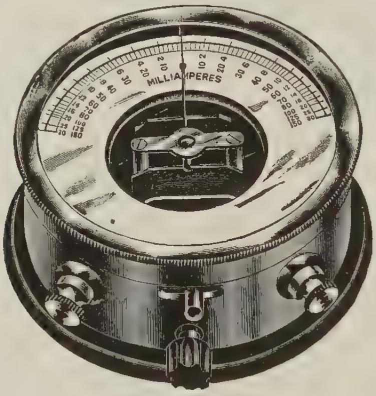

Fig. 3
Milliameter.

action upon irritated nerves, thus soothing pain. Acting as a vaso-constrictor, it decreases the supply of blood to a part and thus reduces inflammation, as well as acting as a hemostatic. Where there is pain without accompanying inflammation, it will exert its influence upon sensory nerves to relieve the pain. The positive pole (anode) decreases local body heat; it is acid, hardens the tissues and is somewhat antiseptic in character. (A theory is advanced by some physio-therapeutists that bacteria are either positive or negative in their charge and are therefore like ions carried to the pole which is the opposite of their own charge. This has not been conclusively demonstrated).

Local application of the cathode exhibits an opposite action to the anode and has a stimulating effect upon irritated nerves,

thus producing pain. It is a vaso-dilator, causing more blood to flow to a part, thus increasing hyperemia, inflammation, congestion and hemorrhage. It is alkaline, softening and liquefying tissue and thus creating a field for the propagation of germs. The negative pole increases local body heat. When the current from the cathode passes through a part in which there is active inflammation, or a stasis (stagnation) as an abscess, ulcer or malignant growth, pain will result. In this way is deep seated pathology often detected.

The nerves of smell, taste, sound and sight are especially susceptible to stimulation by the galvanic current as evidenced by an increase in function and in the case of the optic nerves, flashes of light.

Application of the galvanic current to nerves and muscle will produce muscular contraction providing nerve degeneration is not complete and the muscle capable of contracting. Deeper and more pronounced muscular contractions are secured by the use of galvanism than any other mode. Muscle fibres contract only at the moment of making and breaking the current, during the interim, while the current is flowing, chemical action is produced, but no muscular contraction. Muscle contraction is more pronounced and vigorous when the current is broken (switched off) than when it is made (switched on).

The **Interrupted Galvanic** current is a galvanic current the steady flow of which from positive to negative pole is interrupted or broken by a special mechanical contrivance (rheotome) which regulates the number of interruptions per minute. The same effect may be produced by the use of an interrupting handle used by the operator.

This type of galvanism is used in an effort to produce contraction in paralyzed or partially paralyzed muscles, in treating diseases of the nerves and in testing for nerve degeneration. The latter use is an important one, for the interrupted galvanic current will produce muscular contractions when other currents fail and as a diagnostic agent in nerve degeneration has no equal, but as a treatment current in muscular and nerve conditions it is far sur-

passed by the rapid surging sinusoidal and slow galvanic sinusoidal currents, which will be discussed under the latter subject.

General Galvanism temporarily acts as a stimulant, followed later by a sedative action upon the nervous system, allaying nervous irritability and pain and facilitating sleep. General nutrition is improved by its influence upon the circulation and lymphatic system, thereby promoting metabolism. Body temperature is lowered.

Ionic Medication; Ionization and **Phoresis** are synonymous terms applied to the process of forcing medicinal substances into the tissues by means of the galvanic current.

The principle of ionic medication is based upon polarity, the migration of ions and the law that likes repel and unlikes attract. If a certain drug is to be driven into the tissues, the first thing which must be considered is the nature of the charge carried by the ions of the drug or chemical, and when this is ascertained, its application under the appropriate pole.

For example, we wish to introduce iodine, which is an anion (electro-negative element), into the tissues. A pad consisting of several thicknesses of gauze is moistened with a solution of potassium iodide and placed smoothly over the area to be treated. Upon this is laid a flexible metal electrode the same size and shape as the pad and upon the opposite surface of the limb is applied a larger electrode well wet with salt solution. The two electrodes are then bound firmly in position by a few turns of elastic bandage.

Where shall we attach the two galvanic terminals? We clip the negative terminal to the active electrode covering the pad wet with the solution of potassium iodide, because the iodine of this compound is an anion (electro-negative) and we wish to repel it by negative polarity. The larger indifferent electrode is clipped to the positive terminal. When the circuit is slowly opened, the current energizes the negative iodine ions and as they are under the negative pole they are forcibly repelled through the tissues in the direction of the positive pole (anode) which is meanwhile assisting their migration by its attractive, unlike force.

Drugs or chemicals to be driven into the tissues must be in solution. They are divided in two classes, namely: Anions, which are clectro-negative ions attracted to the anode, and Cations, which are electro-positive ions attracted to the Cathode. Thus a drug or chemical used in ionic medication is known by the name of the pole to which it travels.

Cations.

Zinc, best obtained from a 1% solution of zinc sulphate.

Magnesium, best obtained from a 1% solution of magnesium sulphate.

Lithium best obtained from a 1% solution of lithium chloride.

Ichthyol, best obtained from a 1% agueous solution.

Copper, best obtained from a 1% solution of copper sulphate.

Mercury, best obtained from a 1% solution of mercuric chloride.

Quinine, best obtained from a 1% solution of quinine hydrochloride.

Cocaine, best obtained from a 1% solution of cocaine hydrochloride.

Morphine, best obtained from a 1% solution of morphine sulphate.

Adrenalin, best obtained from a 1 to 1,000 solution of adrenalin chloride.

Silver, best obtained from a 15% solution of silver nitrate.

(All alkaloids are cations)

Anions.

Iodine, best obtained from a 10% solution of potassium iodide.

Chlorine, best obtained from a 2% solution of sodium chloride, two teaspoonfuls to a pint of water.

Salicylic Acid, best obtained from a 1% solution of sodium salicylate.

An easy way to remember under which pole a solution is placed for ionization is to recall the chemical name and consider the first part of the salt as positive and the second part negative. For instance—potassium iodide. Potassium is electro-positive and iodine

electro-negative. If you wish to drive in the potassium of the salt, apply it under the positive pole or anode; if the action of iodine is desired, apply the solution under the negative pole or cathode. Of the salt quinine bisulphate, quinine is a cation and the acid constituent an anion.

Among some practitioners it is the custom in ionization of salts to reverse the poles from time to time during a treatment and thus secure an opposite ionizing action. This is of little practical value.

The current used in the practice of ionic medication should be of low milliamperage and closed and opened gradually to avoid pain. The results secured from this method of treatment come slowly after many treatments, consequently they should be frequently repeated. The length of treatments depend upon the depth and density of the tissues to be treated; lesions of the foot requiring from ten to thirty minutes.

Electrodes may be of felt, sponge, asbestos or several thicknesses of gauze wet with the medicated solution laid over the desired area and covered with a circular block tin electrode to which the terminal is clipped. Powdered potters clay wet with the solution, moulded over the part and covered with a piece of copper gauze, of equal shape and size, to which is attached the terminal makes a very practical electrode for foot treatments.

The electrode under which the medicament is used is called the active electrode, while its fellow is known as the indifferent electrode and is placed upon the part opposite to the active, but as near it as possible in order to reduce tissue resistance.

A divergency of opinion exists as to the practical results obtained by ionization. There is no doubt but that chemicals may be introduced into the tissues in this manner. It is quite simple to anaesthetize the skin by the ionization of cocaine hydrochloride, but the anaesthetization goes no (or but little) deeper than the skin. As soon as the ionized substance passes into the subcutaneous tissues, it is absorbed by the blood and lymph streams and whisked away into the general circulation. Again, when it

is considered that an ounce of the two per cent solution of the various salts used by this method contains only 9.2 grains of the salt and that a great part of the solution is not absorbed by the skin, but held in the electrode, it will be seen how little of the drug comes in contact with the deeper structures.

In considering the various ionizing agents, it will be noted that it is necessary to use them under the pole which in ordinary galvanic treatment would be the one used irrespective of ionizing technic. For example, we know that the negative pole (cathode) would be the one used if we wished to soften and hasten the breaking up of scar tissue, adhesions, etc. In such cases, in fact, it will have this action with or without chlorine ionization. Consequently the question arises as to the real worth of ionic medication. Does the drug combined with the current really enhance its action? At any event ionization is not practical in deep seated lesions, although its results are demonstrable in superficial work.

Electrolysis is the breaking up of a compound substance by the use of electricity. In medicine it is applied to the destruction of tissue by the chemical action of the ions liberated by the galvanic current. It is also known as Surgical Ionization.

Electrolysis is used for the destruction of small growths, moles, papillomata, verrucae, superfluous hair, etc. The principle of electrolysis rests upon the chemical action produced by the poles of a galvanic current. No other current can be used for electrolysis.

We now know that the oxygen (acid forming) ions of the negative pole are repelled to the positive pole (anode) and that the reaction of tissues under this pole or electrode will be acid, due to the formation of hydrochloric acid. We also know that the positive pole gives off hydrogen ions, which being repelled by it, collect around the negative pole (cathode) in the form of sodium hydroxide or caustic soda, giving the tissues about this electrode a decided alkaline reaction. Consequently in the destruction of

tissue by electrolysis we have the choice of two chemical agents —we may use an acid or an alkali.

The technic which we will later discuss under the subjects of papillomata and verrucae will explain that a needle attached to one pole of a galvanic current is introduced into the tissue to be destroyed, while the other or inactive electrode will be placed at some nearby part of the body. The circuit being closed, ionization takes place about the needle within the tissues creating a chemical which destroys them.

Now which pole shall we use as the active one, the acid or the alkaline? The acid pole has the same effect upon the tissues as a corrosive acid, causing coagulation of albumen, shrinking and hardening of the tissued with a superficial, dry, white, hard cicatrix or scar. The negative alkaline pole exerts the same effect as an application of caustic soda, it does not shrink the tissues, but on the contrary, produces a deep, red, moist, softened condition.

Experience has proven this the best agent and consequently the negative needle is the one generally used in the destruction of foreign growths and superfluous hair by electrolysis.

Therapeutics.

The galvanic current as such has a comparatively small field in chiropody, but when modified as in the slow galvanic sinusoidal, it is almost indispensable.

In selecting the various pathological conditions in which galvanism may be used, we must always bear in mind its distinct polar action. The positive pole (anode) being acid and sedative, the negative pole (cathode) being alkaline and stimulating; while the interrupted galvanic current will produce the most energetic muscle contraction of all currents and demonstrate this reaction in degenerated nerves which fail to respond to the stimulation of other currents. These are the key notes in galvanic therapy.

In paralysis following peripheral nerve degeneration, whether from traumatism or disease, the interrupted galvanic current is

used for muscle testing if the faradic or rapid sinusoidal currents have failed to elicit muscle reaction. The subject of muscle testing will be considered in detail subsequently.

That particular phase of metatarsalgia known as Morton's Neuralgia, in which there are well defined reflex symptoms as a

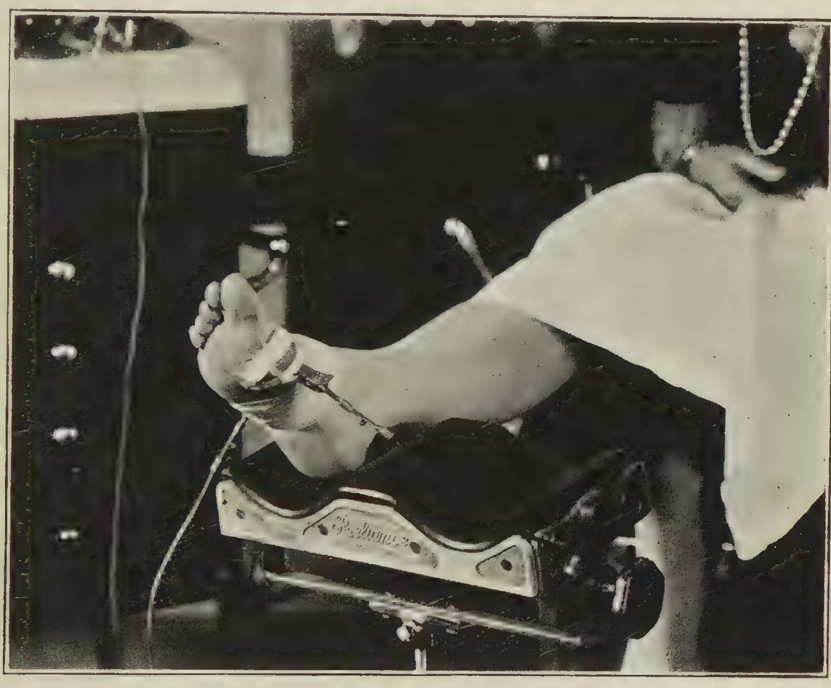

Fig. 3A

Method of Treating a Chronic Bursitis, or Bunion, of the First Metatars-Phalangeal Joint by Negative Galvanism. Adhesive Plaster Strips Are Used That the Moulded Felt Electrode, Backed up with Perforated Block-Tin, May Be Seen. The Softening Action of Negative Galvanism Is Increased by Wetting the Felt with a Solution of Sodium Chloride and Thus Obtaining Chlorine Ionization. The Large Indifferent Electrode Is Bound upon the Outer Border of the Dorsum of the Foot by an Electric Bandage.

result of mechanical pressure, especially in those of neurotic temperament, is frequently benefited by the use of positive galvanism.

Acute Neuritis, especially that localized, as in plantar neuritis, at times requires positive galvanism in conjunction with heat and light treatment. The fibrositic changes in chronic neuritis call for the softening action of negative galvanism.

In Neuralgia, positive galvanism is used for its sedative effect as well as its ionizing action in driving quinine hydrochloride or other appropriate drugs into the tissues. Where it is desired to obtain the action of salicylic acid in neuralgic pains the negative pole is used in ionizing a solution of sodium salicylate.

Arthritis is frequently treated by general galvanism, while chronic localized arthritis with fibrosis calls for the application of negative galvanism over the affected area.

Combined with diathermia positive galvanism is used in Thrombo-arteritis Obliterans.

Chronic Bursitis, whether of the first or fifth metatarso-phalangeal joints (bunion), Achillo bursa or elsewhere, offers a field for negative galvanic ionization of iodine, using a solution of potassium iodide for the purpose. The softening action of the cathode combined with the alterative effect of the iodine ions upon the superficial fibrosity is bound to result in its absorption and destruction if continued for a sufficient length of time. Diathermia, negative galvanism and vibration, used in the order given is the proper procedure in chronic bursitis. Where calcification of the bursa has occurred or a complicating hallux valgus has resulted in bony changes, physio-therapy is not indicated.

In fact, wherever we find over-growth of fibrous connective tissue, be it in the soft tissues or an ankylosed joint, the continued application of negative galvanism is indicated to soften and liquefy the fibrous tissue and where the fibrosis is not too deeply seated, chlorine and iodine solutions should be used under the cathode to take advantage of the ionizing effects secured by that pole.

In the chronic stages of Pernio (chilblain and frostbite) and Trench Foot where the vessels are fibrosed, negative galvanism may be considered and is worthy of a trial. Acute chilblains would require the sedative action afforded by the positive pole, so applied that the current will traverse the entire area of stasis.

Papillomata, Verrucae, Moles, Naevi may all be destroyed at

one treatment, under local anaesthesia, by negative electrolysis, but as the resulting wound is more or less devitalized, it is more likely to become infected than the bloodless, sterile wound created by surgical diathermia.

Galvanic Technic.

Never use the galvanic current without checking up the polarity. See that your electrodes are sufficiently wet, in good application and that all connections are tight. In starting treatment, open the rheostat slowly, gradually increasing the milliamperage until the desired dosage is reached. After the current has passed through the tissues for a short time, reduce the current a little and then if not uncomfortable to the patient, hold it at that milliamperage. If the patient complains of pain before you have reached the desired dosage, go over your electrodes to be sure they are in close application to the skin and no sparking exists. Being assured that everything in good order and the patient again complains of pain or decided discomfort, be content to use a smaller dosage than you had intended. Remember that tolerance varies greatly in different individuals. If your positive electrode is the active one, be sure it is not too small or too long applied, the tissues under it develop an acid reaction and this may mean cauterization.

The galvanic current is not an agreeable modality, so do not attempt long treatments and be content with moderate dosage. Reduce the current, as you increased it, gradually. Remember that you produce muscular contraction at the making and breaking of the current. If you close and open with high milliamperage, you will subject the patient to painful shocks. Never move or remove an electrode, or reverse poles, while the current is flowing—open the circuit and make the desired changes.

Galvanic electrodes usually consist of circular metal plates fitted to a handle and covered with felt, asbestos, sponge or several layers of gauze. These are usually the smaller active or treatment electrodes. The indifferent electrodes are considerably larger

and consist of felt, asbestos or gauze pads attached to heavy, flexible rubber backs which more readily conform to the surfaces to which they are applied. In chiropody it is frequently difficult to apply an electrode owing to the bony prominences and the thinness of the soft tissues upon the dorsum of the foot and over the joints. In such cases it is necessary to cut an electrode from 22 gauge block tin, trim it to size and shape and after covering the treatment area with from four to six smooth layers of gauze, wet with salt solution, bind it snugly upon the gauze with a few turns of an elastic bandage.

A more adaptable electrode is made by moistening finely pulverized potters clay to a consistency which will mould easily over the part and covering it with a piece of copper mesh cut the size and shape of the clay pack, pressing it into the clay and attaching the terminal clip to it. The clay should be sufficiently moistened with salt solution to lessen its resistance, but not enough to make it too soft to mould with the fingers. The thickness of the clay electrode should be from one-quarter to one-half of an inch. When it is desired to practice ionization, a solution of the desired drug is used to moisten the clay.

In attaching clips to electrodes always attach the clip on the active electrode to the margin farthest from the indifferent electrode.

When a localized area is to be treated upon the foot, apply the active electrode (the smallest one) over the pathalogic area and the larger indifferent electrode upon the opposite side of the foot, trying to avoid as far as possible bony or thinly covered prominences. When a more general galvanization is required, as for instance through the entirety of an inflammed nerve, apply the active electrode upon the foot and the indifferent electrode over the main nerve trunk higher up on the leg or thigh.

Always wet all electrodes used in applying the galvanic current with a solution of common table salt, or if an ionizing effect is desired, with a solution of the drug which is to be driven in by the appropriate pole.

CHAPTER III

FARADIC CURRENT

Definition; Production and Apparatus; Properties; Physiological Action; Therapeutics; Technic.

Definition.

The Faradic current is an induced, alternating, interrupted current of high voltage, low amperage and medium frequency.

An Induced current is one generated in a body by the influence of another electrified body.

An Alternating current is one in which there is no fixed polarity, the current flowing first in one and then in the opposite direction.

By Frequency is meant the rate per second at which the alternating current changes its polarity, or reverses its direction of flow. For example: the flow of current from positive to negative constitutes one alternation and its return flow from negative to positive another alternation.

A Cycle consists of two alternations, a circle so to speak.

Production and Apparatus.

To understand the principle of electrical induction we must reconsider the construction and action of the electro-magnet. We know that if a soft rod of iron is wound with a few turns of coarse wire, the ends of which are attached to the two poles of a galvanic cell, the passage of the current will develop magnetic properties in the iron core, making it possible to attract small particles of metal and throwing out *lines of force* in all directions, much as heat waves radiate from the top of a hot stove. We also know that when the current ceases to flow through the wire, the iron core loses its magnetic force and the lines of force sink back upon the wire coil.

From now on let us think of the electro-magnet as a primary coil. Another, or secondary coil, is made of many turns of very

small insulated wire with an opening through its center, spool fashion, large enough to admit the primary coil. The two ends of the wire constituting the secondary coil are attached to an instrument used for detecting the passage of electrical currents known as a galvanometer.

The primary coil is now electrified by attaching it to the poles of a galvanic cell and is slipped inside the secondary coil. Instantly an induced current is set up in the secondary as shown by the galvanometer needle, which vibrates for a short time and then turns back to its neutral position, showing that the electrical impulse has ceased. The primary coil is now withdrawn from the secondary and immediately another passage of induced electricity takes place as shown by the galvanometer, but the direction of this second flow of current is *opposite* to that of the first. In other words the current *alternates* with the *make* and *break* of the circuit and not only that, but the voltage of the induced current in the secondary coil is much higher than that of the primary, inasmuch as the many turns of secondary winding cut the many lines of force thrown out by the coarse primary winding.

A Transformer is a modification of this principle in which the primary coil is connected to an alternating current. If the voltage is increased in the secondary coil, it is known as a step-up transformer, but if the number of wire turns in the secondary coil are less in number than in the primary, it is known as a step-down transformer, for there are fewer lines of force cut by the fewer secondary windings and consequently the voltage will be less than that of the primary coil. The voltage of a secondary coil is dependent upon the ratio of its windings to that of the primary.

A Faradic or Induction coil is based upon the principles just enumerated, the making and breaking of the current being accomplished by a magnetic device consisting of a small flexible lever or vibrator which swinging back and forth opens and closes the circuit, energizing the primary coil and inducing a high voltage alternating current in the secondary, which is the current received by the patient.

Faradic or Induction Coil. This appliance consists of a core of iron, or, still better, a bundle of soft iron wires A (Fig. 4), around which is wound a few turns of coarse wire constituting the primary coil. One end of the primary winding is attached to the negative pole of a battery, the other end is connected with the base of a flexible steel spring C, upon which is fastened a soft iron hammer B. The hammer presses against the point of a screw D, which runs through an upright post attached to the positive pole of the battery.

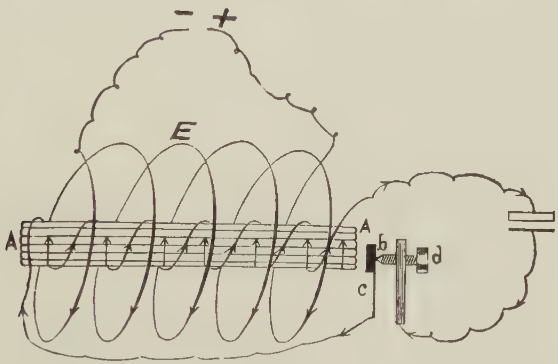

Fig. 4
Faradic or Induction Coil.

When the attachment is made the current passes from the positive pole through the contact screw, hammer, steel spring, primary coil and back to the negative pole of the battery, thus completing the galvanic circuit. But the instant the primary coil is energized, lines of force are thrown out which induce a current in the secondary coil E, which flows in an opposite direction to the primary current, and at the same time magnetizes the iron core which attracts the hammer B to it, thus breaking the circuit at the screw point. Immediately the primary current ceases to flow, the lines of force sink and the current in the secondary coil reverses its direction, producing the second alternation. As the core loses its magnetic force, it can no longer hold the flexible steel spring and hammer to it and consequently they swing back, make contact with the screw point and complete the circuit, when

the entire action is repeated. The rapidity of the alternations produced by a Faradic coil is governed by the screw contact point, which being brought nearer the end of the coil permits the iron hammer to vibrate through a shorter distance, thus increasing the rate of vibration which means increasing the rate of alternations.

The automatic make-and-break appliance of the Faradic coil accomplishes the same result as introducing a primary coil within a secondary and then withdrawing it by hand. The making of the current inducing a secondary current in one direction and its breaking creating a flow in the opposite direction i. e. alternating the current. (Fig. 5.)

The Bristow Coil is a modification of the Faradic, (Fig. 6) in

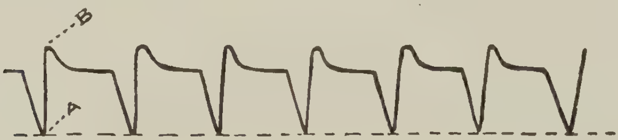

Fig. 5
Tracing of Faradic Current.
A, Make: B, Break.

which the secondary winding is of coarse wire with the number of turns greatly reduced. Thus the lessened turns reduce the voltage, while the lower resistance in the large wire delivers a higher amperage than that of the Faradic coil and with the slower rate of interruptions makes it a valuable modality in muscle testing and treatment. A sinusoidal effect can be derived from the current furnished by the Bristow coil by sliding the core, with which it is equipped, in or out.

Properties.

The character of the Faradic current varies with the voltage which is high, from 1,000 to 50,000; the amperage which is low, 1/1000 to 1 milliampere; and the frequency of interruptions which is medium, about 1,000 per second.

The production of this current is the result of mechanics. There is no electrolyte, no metal to be decomposed and no chemical

action, consequently there is no decided polarity. Manifestations of the secondary current occur only at the make and break of the primary current. (Fig. 5.) There is no metallic connection between the patient and the primary coil, and while the current flowing through this coil is a simple galvanic current the induced

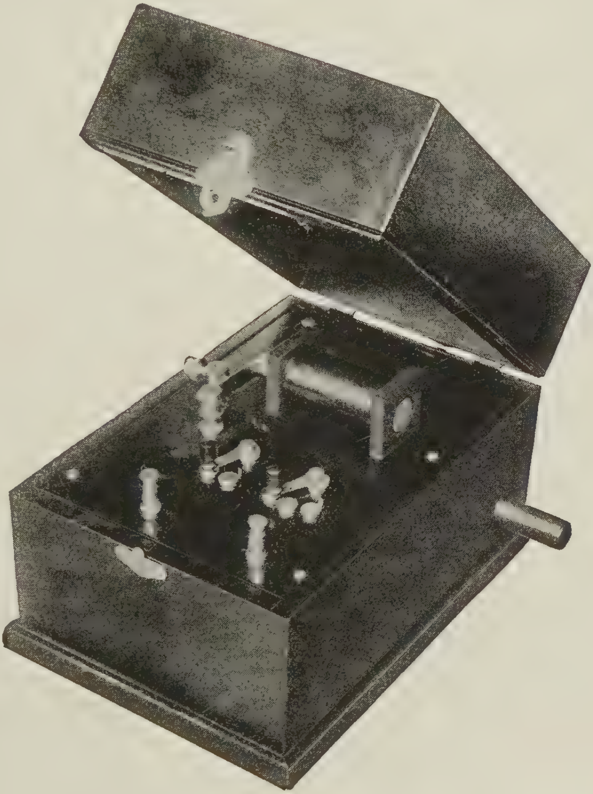

Fig. 6
The Bristow Coil.

current delivered to the patient by the secondary coil is of an entirely different type, an extra current, so to speak.

Physiological Action.

Since the physics of the Faradic current are entirely mechanical the physiologic effects rest upon a mechanical basis. It is, of course, understood that every mechanical motion or movement

of the body influences the chemistry of the same accordingly. Whatever chemical changes are produced in the body, as the result of the application of the Faradic current are the direct result of the tissue contraction and relaxation, and not the primary effects of the current.

Therapeutics.

The administration of this mode imparts a series of shocks, caused by the interrupted flow, and has the same mechanical effect upon the tissues as a gentle pounding, tapping or massaging of the parts, extending even to the deeper tissues. A current of low voltage and slow interruptions, 1 to 30 per second, acts principally upon the muscles and motor nerves, producing intermittent or clonic muscular contractions; while a current of the same voltage, but of higher frequency, produces a continuous or tonic muscular contraction.

In testing for nerve degeneration the low tension, slowly interrupted Faradic should always be tried first (if this is not obtainable the rapid sinusoidal) and if no response is obtained, it is to be followed by the interrupted galvanic.

In cases of acute pain, other than those associated with inflammation or septic infection, as neuralgia, the high voltage Faradic with rapid interruptions may be used. This applies also to sensory disturbances.

The low tension Faradic with slow interruptions is used therapeutically to promote muscular growth, to relieve stiffness due to disease or traumatism and to promote absorption of exudates.

The low voltage, slowly interrupted current produced by the Bristow coil is indicated in the treatment of weak, flabby muscles in which voluntary motion still exists. In these cases painless muscular contractions may be secured whch would not be possible with the ordinary Faradic current.

Judged by its actual physiological effects there is no doubt but that Faradism is the least important of the various electrical modes

used in medicine. Its place is well taken by the high frequency, rapid and slow sinusoidal currents.

Technic.

The application of this current, placing of electrodes and regulating of dosage is practically the same as that described under the subject of galvanism. While the Faradic current is an alternating one, nevertheless the alternations are not of equal value. There is a polar difference, although of course it is not as well marked as that of the galvanic current and need not be considered so particularly. The negative or break pole is stronger than the positive or make pole. As a general proposition the positive pole may be considered sedative, while the negative pole is irritative and muscle stimulating.

CHAPTER IV

THE SINUSOIDAL CURRENTS

Definition; Production; Types; Physiological Action; Therapeutics; Technic.

Definition.

A Sinusoidal Current is one in which the potential or voltage gradually rises to a maximum and then recedes to zero, at which point the current is reversed, without being interrupted, and gradually rises to a maximum in the opposite direction, followed by another fall to zero. The term sinusoidal is used because the graphic representation or voltage tracing follows the trigonometrical "curve of sines." In a true sinusoidal current the phases or alternations are equal, thus eliminating polarity and placing it among the mechanical modalities. (Fig. 7.)

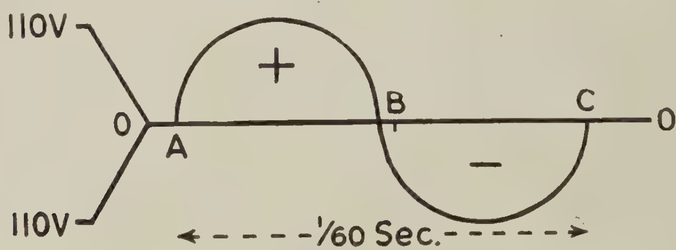

Fig. 7
A to B Positive Phase. B to C Negative Phase. A to C One Complete Cycle Consuming 1/60 of a Second.

Types of Sinusoidal Currents

A Cycle consists of two alternations or phases, namely, one positive wave or phase and one negative wave or phase; or to express it in another way, of a positive sine and a negative sine.

The term frequency is used to express the number of cycles or alternations occurring per second. Thus a 60 cycle current has 60 positive alternations or phases and 60 negative alternations or phases, making a total of 120 alternations per second. This is the frequency of the usual commercial alternating current.

The sinusoidal currents are classified in various ways. By some they are referred to as rapid, fast and slow, having reference to the rate of their alternations per second, but I shall consider them as rapid or slow, for the following reason;

Normal muscle responds to electrical shock or stimulation by

Fig. 7A

Exercising the Anterior Muscles of the Leg by the Slow Sinusoidal Current. The Large, Felt, Indifferent Electrode Being Bound upon the Inner Border of the Sole and the Smaller Active Electrode, with Interrupting Thumb Switch, Placed over the Motor Point of the Tibialis Anticus Muscle. Note Adduction and Inversion of Foot as the Muscle Producing This Motion Is Stimulated.

contraction of its fibres. When the circuit is broken, or reversed, the muscle again contracts. Between the making and breaking of the current, during its actual passage, there is no muscular contraction. A muscle is incapable of contracting more than about 30 times per second.

If the frequency of the electrical current is more than 30 alter-

nations per second, the muscle cannot react to each electrical shock and responds by going into continuous or tonic contraction. When the frequency is below 30 per second, the muscle contracts with each alternation. Consequently I shall consider sinusoidal currents that have a frequency of not more than 30 alternations, or 15 cycles, as Slow, and those that have more than 30 alternations per second as Rapid.

The Rapid Sinusoidal current is the ordinary commercial alternating current, with a usual frequency of 60 cycles, (120 alternations per second, or 7,200 alternations per minute.) (Fig. 8.)

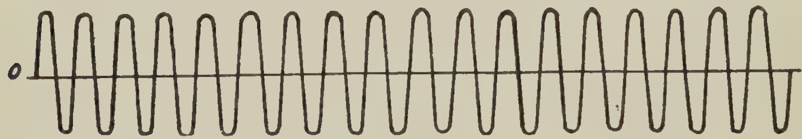

Fig. 8

Graphic Representation of Rapid Sinusoidal Current.

The Surging Rapid Sinusoidal is the rapid sinusoidal modified to produce a surging effect or wave. (Fig. 9.)

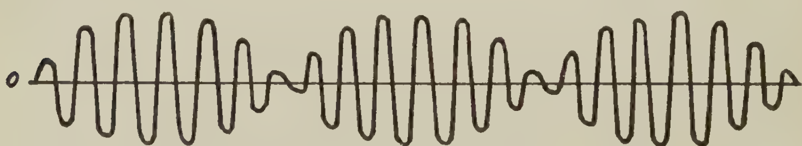

Fig. 9

Graphic Representation of Surging Sinusoidal.

The Interrupted Rapid Sinusoidal is another modification in which the rapid sinusoidal is broken or interrupted at regular intervals. (Fig. 10.)

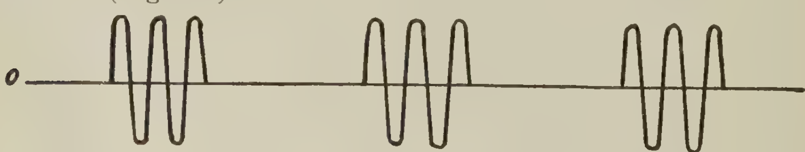

Fig. 10

Graphic Representation of Interrupted Rapid Sinusoidal.

The Slow Sinusoidal current is the straight galvanic current modified by mechanical means so that the polarity of each suc-

ceeding sine or phase is reversed, thus neutralizing all polarity effects. (Fig. 11.)

Fig. 11
Graphic Representation of Slow Sine Wave.

The Surging Galvanic is not a sinusoidal current, but a true galvanic current with a gradual rising and falling potential. It, of course, exhibits the typical polar effects of the direct current and is mentioned at this time, under this heading, because it is included with sinusoidal currents furnished by modern sinusoidal outfits. (Fig. 12.)

Fig. 12
Graphic Representation of Slow Surging Galvanic Current.

The Superimposed Wave is a surging slow sinusoidal in which the smooth sine wave is modified and replaced by a series of

Fig. 13
Graphic Representation of Superimposed Sine Wave.

secondary impulses, with gradually increasing and decreasing potential, as the polarity of each phase is reversed. (Fig. 13.)

Production of Sinusoidal Modes.

The Rapid Sinusoidal may be used directly from the alternating street circuit after passing it through a rheostat to control the voltage. Many of the old and cheaper outfits consist of this and nothing more. However its use in this manner is hazardous practice, for a short circuit may cause unpleasant or even fatal results.

The better type of sinusoidal outfits include a generator producing a rapid sinusoidal mode which is ground free and independent of the street current. In such appliances the frequency varies, some running about 30 cycles per second, while another develops 360 cycles, permitting the use of high voltage. (Fig. 14.)

The slow Sinusoidal current is produced in most sinusoidal machines by a motor generator which develops a ground free direct current. This current is then modified by passing it through a resistance coil or block which is so arranged that the voltage is constantly and symmetrically raised and lowered, with the result that each succeeding wave is of the opposite polarity to that of the preceding one, thus neutralizing all polarity effects.

In some sinusoidal machines this resistance coil revolves against brushes, in others the brushes revolve against the resistance, while in another outfit various shaped cams are used which raise and lower resistance and thus modify the current wave. The slow sinusoidal current developed by most outfits may be regulated to deliver from 20 to 340 alternations per minute.

The various modifications of the rapid and slow sinusoidal modes are produced by special adjustment of rotors, resistance coils or cams, the underlying principle being the same.

Physiological Action.

In considering the true sinusoidal currents we must not overlook the fact that they are essentially mechanical modalities, without polarity effects, and while the currents have the same general characteristics of the Faradic current yet they are less painful and irritating, due to the fact that the current wave is smooth, rhythmical and uninterrupted. Consequently stronger currents may be used and better results obtained than by the use of the Faradic. Again, the sinusoidal current will produce contraction in involuntary (unstriped) muscles as well as muscles cut off from throphic (nutritional) centers, in which we get no contraction from the Faradic.

The Rapid Sinusoidal possesses one feature of the high frequency current, that is, the greater its rate of alternation the less

painful the current. The absence of pain is supposed to be due to the inability of the sensory nerves to comprehend such rapid alternations, just as we have vibrations that cannot be recognized by the auditory nerve as sound, or by the eye as light.

As a result of its rapid vibratory impulse the rapid sinusoidal produces a cellular massage which increases and stimulates local metabolism, probably as a result of the deep hyperemia and the awakening of nerve conduction. Used in small dosage, that is, voltage insufficient to cause muscular contraction, and with short application, the rapid sinusòidal exerts a sedative effect upon painful areas and sensitive nerves, but when larger doses are administered for a longer period it over-stimulates and inhibits. Local heat is increased by a prolonged application of the rapid sinusoidal and the absorption of effusions is thereby accelerated. Used in sufficient voltage it produces tonic contraction or spasm of muscle tissue, which persists as long as the current flows.

Generally speaking, then, the rapid sinusoidal may be considered as a stimulating current to muscle and nerve structure when used in small dosage for short intervals. Prolonged use causes over-stimulation and inhibition. This mode should never be used through or near the heart as its influence upon the heart muscle might produce heart block and fatal results.

The Slow Sinusoidal current produces clonic contraction of muscles without break or interruption as the result of the rhythmic sine wave, which is without polarity. It is essentially a mechanical, muscle exercising modality and any effects which it may exert upon atonic muscle structure are those following regular and judicious exercise.

Therapeutics.

With the exception of the high frequency currents the sinusoidal modes are the most valuable physical agencies used in chiropody. Generally speaking their field is limited to sub-acute and chronic conditions found in the leg and foot, although they are distinctly indicated in certain acute cases.

In Incipient Weak-foot the muscles of the leg and foot which

have become relaxed and tired from over-use and faulty attitudes are refreshed by the vibratory impulse of the rapid or interrupted rapid sinusoidal current of low voltage and brief application. Local metabolism is stimulated by the tonic action of these currents upon the nerves and blood vessels, relieving the characteristic coldness, numbness, congestion and excessive perspiration due to impaired circulation and muscle tire. This action is enhanced

Fig. 14A

Method of Applying the Rapid Sinusoidal Current to Feet and Legs by the Use of Two Metal Foot-Plates Covered with Gauze Wet with Saline Solution. This Current and the Surging Rapid Sinusoidal Are Valuable for Their Stimulative and Tonic Effect upon Relaxed and Atonic Muscle Tissue, as Found in Peripheral Paralysis and Weak-Foot.

when preceded by a brief exposure of the foot and leg to visible light.

Weakness and loss of muscular tone in the anterior muscles of the leg as a result of early contraction of the powerful calf muscles is relieved in the same manner. Application of the rapid sinu-

soidal should be preceded by heat, vibration and massage to the calf muscles in an effort to secure relaxation and lessen their antagonism toward the weaker anterior group. Never force a weak muscle to increased activity until the antagonism of its opposing muscle or muscles is reduced or abolished.

The pain of Acute Metatarsalgia, due to pressure upon the plantar nerves, may be promptly relieved by a mild application of the rapid sinusoidal mode. These cases must not be confused with those in which the pain is of neuritic origin. Do not use a stimulating modality in acute neuritis—plantar or elsewhere.

In those cases of Morton's Neuralgia occurring in patients of neurotic temperament in which the foot is relaxed and flaccid with no appreciable misalignment of the metatarsal heads the application of the interrupted rapid sinusoidal will allay the nervous irritability and do much to prevent the paroxysms which occur upon the slightest provocation.

Disintegration of Fibrous Adhesions and deposits in and about the joints, whether the result of traumatism or infection, is encouraged by the character of the rapid sinusoidal surging wave. Its application in these cases should be preceded by the use of the diathermia current to soften the tissues, followed by passive motion or deep vibration while the joint tissues are put under tension.

In early Pernio (chilblains) attended with venous stasis and irritation of the sensory nerve terminals a mild application of the rapid sinusoidal or interrupted rapid sinusoidal current for two or three minutes will stimulate the vasomotor constrictors and assist in establishing vascular equilibrium. Diathermia should be used in connection with the sinusoidal mode. Chronic cases usually exhibit an organized fibrosis and require the chemical action of the galvanic current in conjunction with diathermy. Cold extremities not the result of thermic changes are benefited by mild, stimulating doses of the rapid sinusoidal current.

Sensory Disturbances. All morbid general sensations as numb-

ness, prickling, burning, coldness, itching, tickling, etc., which are grouped under the term "paraesthesia," evidence impaired function of the sensory nerves and indicate application of the rapid interrupted current.

In testing for Nerve Degeneration in peripheral paralysis, the rapid sinusoidal (in the absence of the Faradic) should be tried first. If no response is elicited the interrupted galvanic should

Fig. 14
Sinusoidal Apparatus.

next be tried. The cases of paralysis seen by the chiropodist are usually subacute or chronic, in which paralysis is not complete and muscle testing is only required to establish an approximate idea as to the extent of the nerve degeneration. In such cases the rapid sinusoidal will usually produce the desired reaction. This subject will be considered later under the subject of muscle testing.

Therapeutic Application of the Slow Sinusoidal Current. This is the straight galvanic current so modified, by mechanical means, that its graphic representation describes sine curves, in which each succeeding sine or alternation is of the opposite polarity to that of the preceding, with a consequent neutralization of polarity effects. The slow sinusoidal is mechanical in its action and is therefore used for muscle stimulation and exercise.

Weak-foot and Flat-foot. It is in these attitudes of deformity that the slow sinusoidal is especially indicated in the practice of chiropody. Faulty attitudes, over-use and restricted function all result in muscle tire and weakness. Thus the weaker muscles relax and lose their tone which encourages the opposing muscle to over-contract in an effort to balance muscle equilibrium, for it must not be forgotten that there is maintained at all times, in normal muscles, a constant balance or tension between muscles of opposite groups and action.

Spastic Weak-foot presents a typical and exaggerated picture of such a condition. As a result of functional inactivity the anterior leg muscles become atonic and lessen their tension which encourages the abductors and plantar flexors to abnormally contract. This contraction being continued the abductors and calf muscles go into muscular spasm as a result of the irritation produced by over-use.

In this condition the slow sinusoidal is indicted after the spasm of the abductors is dissipated by heat, deep vibration and exercises.

Early treatment should consist of short, mild applications (insufficient to produce muscle contraction) to the anterior muscles for the improvement of local nutrition and muscle tone. Heat, visible light and massage or vibration (mild) should also be included to the same end. As the symptoms of muscular fatigue disappear short applications should be made individually to the anterior muscles using sufficient dosage to produce gentle muscular contraction. From 20 to 30 alternations should be given for a period of from 3 to 5 minutes. Do not over-work a tired, relaxed

or partially paralyzed muscle by long and powerful sinusoidal applications, but rather build up an increased muscle tone gradually by using your modality as a tonic and suggestive force. As the muscle reacts to this stimulation and exercise the voltage may be increased until full muscular contractions are obtained and continued from 5 to 10 minutes.

The same principle of muscle nutrition and exercise holds good in the treatment of Paralytic Weak-foot, and, in fact, to any peripheral paralysis, whether traumatic of infectious. In such pathalogic conditions the initial treatment consists in an effort to hasten nerve regeneration and local metabolism by the use of diathermia, while the use of the slow sinusoidal is deferred until the nerves regain the ability to carry contractile impressions to the more or less atrophied muscle. Then, and not until then, is this mode used; first in tonic doses and then gradually increased to the point of producing stronger and stronger muscular contractions.

Relaxed Acquired Flat-foot offers a fertile field for general muscle stimulation and exercise afforded by the slow sinusoidal modality. The slow to moderately fast sine waves dispel venous stasis by improving arterial and capillary circulation as a result of muscular action. The atrophied adductor and plantar flexors improve their tone when systematically and regularly exercised by the slow sinusoidal or superimposed wave applied slowly and with sufficient voltage to produce firm, but not painful, contractions.

The fibrosis of Rigid Weak-foot demands first the softening action of diathermia, followed by manipulation and deep vibration directed to the restoration of normal motion in the tarsal joints. When this has been accomplished, or at least a partial range of motion has been secured, the surging rapid sinusoidal will do much by breaking up adhesions and assisting in the absorption of fibrous debris. In such cases the application of electrodes should be made in such a manner that the current traverses the fibrosed area, which is usually localized in and about the medio-tarsal joint. A short application of the slow sinusoidal to the foot and

leg as a whole should follow, using sufficient voltage to cause strong contractions.

That type of Hollow Foot attended with contracted sole and calf muscles, lessened dorsi-flexion and more or less inversion of the forefoot, known as talipes plantaris; Shaffer foot; non-deforming club-foot or contracted calf muscles, is another unbalanced muscle condition in which the slow galvanic sinusoidal may be used to advantage after the contracted muscles and plantar fascia are softened and relaxed by heat and stretched by manual or mechanical manipulation.

Irrespective of the cause or deformity the anterior muscles are over stretched, relaxed, weak and more or less atrophied, incapable of energetically combating the pull exerted by the powerful, contracted calf muscles, until their tone is regained and the opposing muscles relaxed.

Hot-air baking, visible light and diathermia are indicated as heating agents, while deep vibration and kneading massage followed by forced dorsi-flexion of the foot are necessary to relax the calf muscles. This having been accomplished the slow sinusoidal mode gradually increased in strength, frequency and duration and applied individually to the adductors and dorsi-flexors is the rational proceedure.

The use of the slow sinusoidal current in the later stages of Sprains and Strains is indicated to restore muscle action and hasten fibrositic absorption.

Technic.

As the sinusoidal current is without polarity the poles may be used indiscriminately, but if one of the modified galvanic currents furnished by various sinusoidal outfits, as for instance the surging or interrupted galvanic, is used it will be necessary to take into consideration the specific action exerted by the two poles and the direction in which the electrical impulse will travel.

In applying the true sinusoidal current the active electrode is generally the smaller and placed over the area to be treated, or at the point where reaction is most desired; while the indifferent

electrode is larger and placed at the other extremity of the limb or muscle to be stimulated, or opposite to the active when a through and through application is to be made, as for instance in treating an ankle joint.

Sinusoidal electrodes are generally made of felt, asbestos, sponge or gauze and are always applied wet. A solution of sodium chloride (common salt), one teaspoonful to a quart of warm water, making a convenient electrolyte. (Fig. 15.)

Fig. 15
Electrode Used in the Application of the Galvanic, Faradic and Sinusoidal Currents.

Electrodes should fit smoothly over the part without creasing or permitting an intervening air space, in order to prevent sparking and consequent discomfort. Where the part is covered with a heavy growth of hair this should be removed for the same reason. It is frequently difficult to adapt the ordinary felt covered electrode to the foot and ankle due to its contour, thin distribution of soft tissue and bony prominences. In such cases pads consisting of four to six layers of gauze, wet with salt solution, may be cut to fit and smoothly moulded over the part. Upon these is laid a sheet of block tin of the same size and shape held firmly in place by a few turns of an elastic bandage. The terminals are then clipped to the tin electrodes of which a margin is left exposed. Upon the leg it is comparatively easy to use the more bulky felt covered electrodes, especially if it is the indifferent one.

When one electrode is used upon the foot and its fellow upon the leg, regardless of their relative size, the terminal is attached to the distal side (that farthest from the body) of the foot electrode and to the proximal side (that nearest the body) of the leg electrode. Failure to do this will exclude several inches of tissue from the zone of treatment, because low frequency electricity will invariably follow the line of least resistance.

In making attachment to electrodes by clips no part of the clip should touch the skin. If inclined to rest upon the skin they should be separated from it by a pad of dry absorbent cotton or a piece of rubber dam.

When electrodes are placed upon opposite surfaces of the foot or leg in order to secure direct penetration through the part the terminals should be clipped to opposite margins, in order that they may be as far removed and as much tissue included in the circuit as possible.

Individual muscle treatment may be given by placing the indifferent electrode upon the sole of the foot (or placing the foot upon a foot plate) and the active electrode over the motor point of the muscle to be exercised. Or one electrode at the origin and one at the insertion of the muscle; or, again, the indifferent electrode may be placed at the bend of the knee over the popliteal nerves and the active over the motor point of the muscle or muscles to be contracted. Again, the foot may be dropped into a shallow tray or pan containing a warm salt solution in which is immersed a small piece of block tin or plate metal attached to one terminal, while the other terminal is attached to an electrode applied to the origen of a muscle or its motor point.

If a porcelain or metal basin is used care must be exercised that the foot or leg does not come in contact with any part of the basin not covered with water, in-as-much as a short circuit might occur with disagreeable results. If there is danger of the skin coming into contact with the pan place a piece of rubber dam, or sheeting, between the skin and the exposed edge of the vessel.

In using the sinusoidal bath, results depends largely upon the

extent to which the foot is covered with the salt solution, what portions are immersed and the relative position of the terminal to the immersed surface. When using this method consider the water between the terminal and the foot as the electrode and the electrical path as the shortest line drawn between the terminal and the other electrode. By exercising a little ingenuity localized areas may be treated in this way.

In cases where individual muscle stimulation is not desired, but rather a general sinusoidal treatment of the feet and legs each foot may be placed in a tray of salt solution with the terminal immersed in each tray at the distal extremity of each foot. The current will then travel up one foot and leg and down the other alternately if a slow galvanic sinusoidal is used, causing a general contraction of the entire muscular structure. Foot plates may be used in place of the foot bath if so desired. Where the resulting contractions are not sufficiently strong due to the resistance offered by the long circuit up one leg and down the other the path may be shortened by placing an electrode just back of each knee and short circuiting the current from one electrode to the other through a short connecting wire clipped to each electrode. Thus the voltage will have only the resistance offered by the feet and legs to overcome and the sine waves will rise to a higher potential with greater contractile force.

Where diathermia treatment precedes the application of the sinusoidal mode, and the same tissues are to be treated, the sinusoidal terminals may be attached to the electrodes used for the diathermia, providing the contact is moist and the electrodes in good apposition.

Make a practice of opening and closing a circuit gradually, unless you wish to obtain the shock caused by abrupt electric impulse. Use the rapid sinusoidal briefly and in moderate dosage if you desire nerve stimulation. Long exposure blunts and inhibits. Do not over-exercise weakened muscle by long, powerful applications of the slow sinusoidal current. Build up muscle tone by gradual, gentle exercise. Accept the patient's statements as to

existence of pain and discomfort and immediately reduce or open the circuit and check up the contacts and connections. If there is any question in your mind as to the sensation and effects produced by the various modalities try them out upon yourself. In so doing you will learn much by experience and possibly develop a more charitable attitude toward your patient.

CHAPTER V

HIGH FREQUENCY CURRENTS

Definitions; Types; Production; Properties; Physiological Action; Therapeutics; Technic.

A high frequency current, as used in physio-therapy, is an alternating (oscillating) current in which the rapidity of the oscillation is so great that living muscle tissue does not contract under each impulse.

The frequency of oscillation runs into hundreds of thousands or millions per second, there being no standard rate or point at which medium frequency ends and high frequency begins.

The frequency developed by an apparatus depends upon its transformer voltage, condenser capacity, resistance, inductance, etc. The proper balance of a high frequency machine is determined solely by its effect upon living tissues. If passage of the current through the tissues is devoid of sensation, painless, relaxing and unattended by muscular contraction, it is a high frequency current.

Types of High Frequency Currents.

In medicine, three types of high frequency currents are used, namely, d'Arsonval, Tesla and Oudin. These differ only in the proportion of voltage and amperage, but as this difference plays an important part in their physiological action the particular type should always be stated in discussing their use.

The **d'Arsonval** or **Diathermia Current,** also known as thermo-penetration, thermo-infiltration, trans-thermia and direct d'Arsonval, is a high frequency current of high amperage and relatively low voltage (compared to the voltage of the Tesla, Oudin or static currents).

The **Tesla Current** is one of high frequency, high voltage and low amperage.

The **Oudin Current** is one of high frequency, high voltage and low amperage.

Production.

The construction of a high frequency apparatus must include the following essential parts: First, a transformer which increases the voltage received by the machine from the alternating street current or special generator. Second, a spark gap which forces the condenser to fill or store up the current. Third, a condenser which in discharging its accumulated electricity through the spark gap increases the frequency of the current. To understand the generation of the high frequency current, it is necessary to understand the principle of the Leyden jar or condenser. (Fig. 16.)

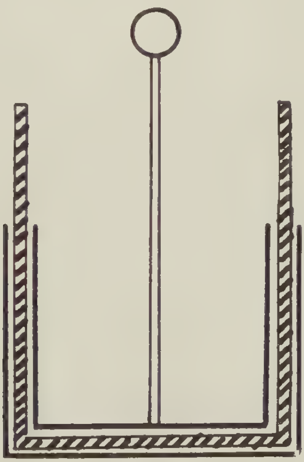

Fig. 16
Section of Leyden Jar or Condenser.

The **Leyden Jar** consists of a glass jar coated inside and out with a layer of tin-foil, which extends about half way up the sides of the jar. Through the wooden cover of jar, a brass rod extends to the inside layer of tin foil upon the bottom of the jar, the end of the rod projecting above the wooden cover terminates in a small knob.

If one pole of a battery, we will say the positive, is touched to the knob upon the end of the rod, the electric current will pass

down into the jar and distribute itself upon the inner lining of tin-foil, spreading over the inner surface of the glass, so to speak. Immediately a charge of negative electricity appears or is *induced* upon the outer layer of tin-foil. We now have a positive and a negative charge of electricity, separated by the glass of the jar, or *dieletric*, which will be held for some time unless a connection is made between them. As more and more positive electricity enters

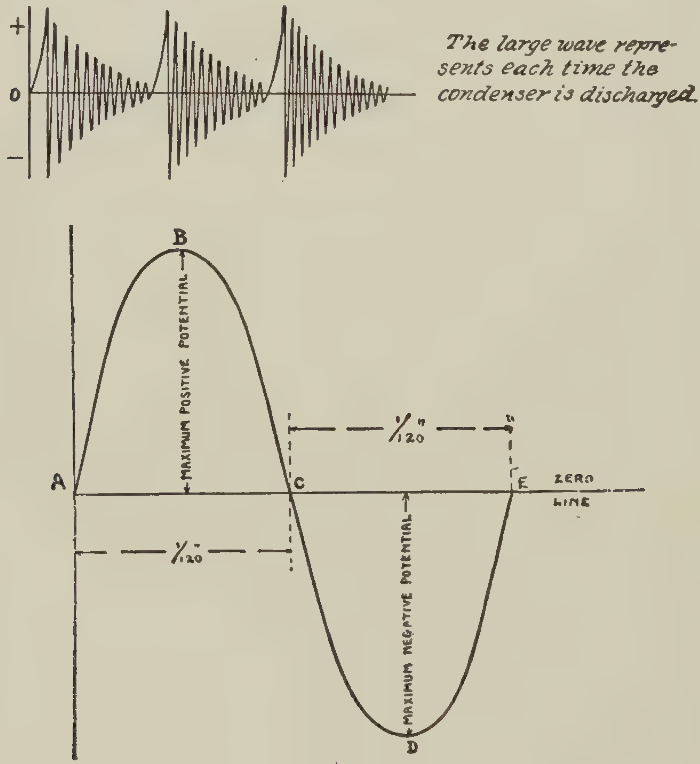

Fig. 17
Graphic Representation of High Frequency Current.

the jar and spreads itself, or is condensed, over the glass, an equal volume of negative electricity accumulates upon the outer surface of the glass. Thus the Leyden Jar acts as a reservoir or storage battery capable of holding a considerable charge of electricity which can be quickly discharged.

If a short piece of wire is bent and one end placed upon the outer coating of tin-foil while the other end is brought near the rounded knob of the brass rod leading to the inside layer of foil, a series of electrical sparks or *oscillations* will take place across the air gap as the positive and negative charges, by their attractive

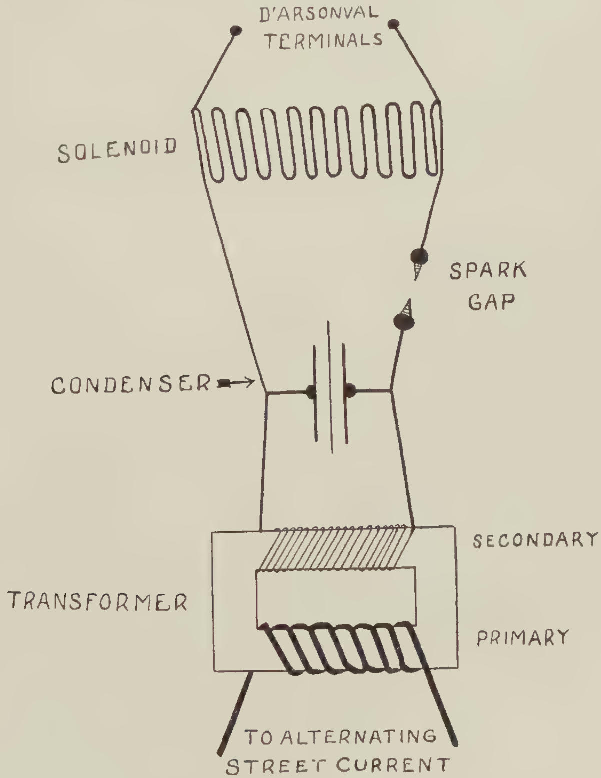

Fig. 18
Diagram Showing Construction of d'Arsonval High Frequency Apparatus.

force, seek and neutralize one another. These electrical oscillations pass *back and forth* at a very high rate, or frequency, gradually becoming less and less until the entire charge of electricity is neutralized.

This phenomenon is known as electrical oscillation and it is upon this principle that high frequency currents are produced.

The path of an oscillating current may be likened to that taken by a clock pendulum which being pulled to one side and released, swings to and fro, constantly lessening its swing or arc until it finally stops in a perpendicular position. (Fig. 17.)

The Leyden Jar is the type of condenser used in most of the larger high frequency outfits, in which case a solution takes the place of the inner lining of tin-foil and serves the same purpose. However, the plate condenser is now generally used as a greater condenser surface can be secured in a more compact form. These consist of alternate layers of glass and tin-foil, or of mica and tin-foil or sheet copper. As the condenser is that part of the apparatus which develops the frequency, and as the rapidity of the oscillations depends upon the amount of condenser charge, it will be seen that an adequate condenser capacity must be provided if an appliance is to deliver a genuine high frequency current.

Let us now consider the construction and action of a **d'Arsonval** high frequency apparatus.

The alternating street current (or the current from a rotary converter) is connected to the primary coil of the transformer, consisted of a small number of turns of coarse insulated wire wound about one side of a rectangular iron frame or core. (Fig. 18.) Upon the opposite side of this frame the secondary coil, consisting of a very much larger number of turns of fine insulated wire is wound.

The alternating current from the street main energizes the primary coil and iron core throwing out magnetic lines of force which, by induction, generate a current in the secondary coil of the transformer. The voltage of the secondary current is much higher than that of the primary, because the many turns of secondary winding cut many more lines of force than do the small number of primary windings, consequently the voltage is raised or "stepped up" in the secondary coil of the transformer. (If the number of secondary turns is less than that of the primary, the voltage will be lowered or "stepped down"). Thus the voltage of the secondary

current depends upon the ratio of the number of turns in the secondary coil to that of the primary.

We now have a current of the same frequency (usually 120 alternations) as the street current but of higher voltage and the next step is to increase the frequency of alternations, and not only that, but to increase the number of alterations from 120 to 1,000,000 or more per second. To do this, we resort to the use of a condenser and spark gap, with a d'Arsonval *solenoid* (a coil consisting of evenly spaced turns of coarse wire) included in the circuit between the condenser and the spark gap.

The two poles of the secondary coil of the transformer are connected to the inside and outside of the condenser (we will consider the Leyden jar as the type of condenser used) and as a single impulse from the alternating current, we will call it the positive charge, flows from the transformer, it is stored upon the inner surface of the Leyden jar and immediately a negative charge is induced upon the outer surface of the glass. As soon as the voltage of this stored-up electricity is high enough, it flows through the solenoid, overcomes the resistance of the air in the break of the circuit known as the *spark-gap* and rushes to the outside of the Leyden jar to neutralize the negative charge of electricity stored upon it. For a brief interval, no current flows due to the neutralization of the positive and negative impulses.

As the current flowed through the solenoid, it threw out lines of force, which always travel in an opposite direction to the inducing current, and as soon as the current ceased to flow these lines of force sink back into the solenoid, their cause being removed, and as they were going in the opposite direction to the original current, flow back into the condenser giving it a negative charge which immediately induces a positive charge upon the outside of the jar—just the opposite from the original condenser charge.

The phenomenon is repeated, back and forth, again and again, causing a continuous spray of sparks to jump back and forth across the spark gap and *creating the electrical oscillations of the high frequency current.*

As the result of the resistance offered by the circuit and spark gap the voltage of the original charge finally dies down to the point where it can no longer jump across the spark gap and a new charge must be supplied the condenser from the transformer.

When we consider that this entire train of condenser charges originated from a single alternation of the current lasting only 1/120 of a second, we can appreciate the frequency of the high frequency oscillations, which are estimated at 1/50,000 of a second, and as the condenser is recharging from the transformer at the rate of 120 alternations per second, it will be seen that the frequency runs up to millions.

The two terminals of the d'Arsonval outfit are attached to each end of the solenoid and from them the patient receives the high amperage, low voltage, Diathermia current. This is a bi-polar current and is never used in any other manner.

Production of Tesla and Oudin High Frequency Currents.

The Tesla and Oudin currents are those having a high frequency, very high voltage and low milliamperage, compared to the diathermia current.

In the better grade of high frequency outfits, one of these currents is found in combination with the diathermia current, being generated by a separate coil or resonator connected to the d'Arsonval solenoid, which has just been described. There is no difference between the milliamperage and frequency of the Oudin and Tesla if they are connected to the same d'Arsonval apparatus and both wound to give the same voltage. The difference being in the *character* of the electrical oscillations produced, which results in the Tesla current producing a more irritating impulse or "hot spark"; while the impulse derived from the Oudin current is less irritating and known as a "cold spark". However in some of the modern high-class outfits the Tesla resonators are so constructed that the irritating effects previously experienced are practically absent.

The Tesla current may be used from one or two poles. In chiropodial work, its use is limited to uni-polar applications. It

is not a diathermia or heat-producing current. The Oudin current is *always* used from one and only one pole.

Production of the Tesla Current. The Tesla resonator consists of a primary coil each terminal of which is connected to the two extremities of the d'Arsonval solenoid and a secondary coil which is made up of a very large number of finer windings. The secondary coil is separated from the primary by an air space of several inches, which acts as an insulator. It forms a separate circuit and with it the patient is connected. (Fig. 19.)

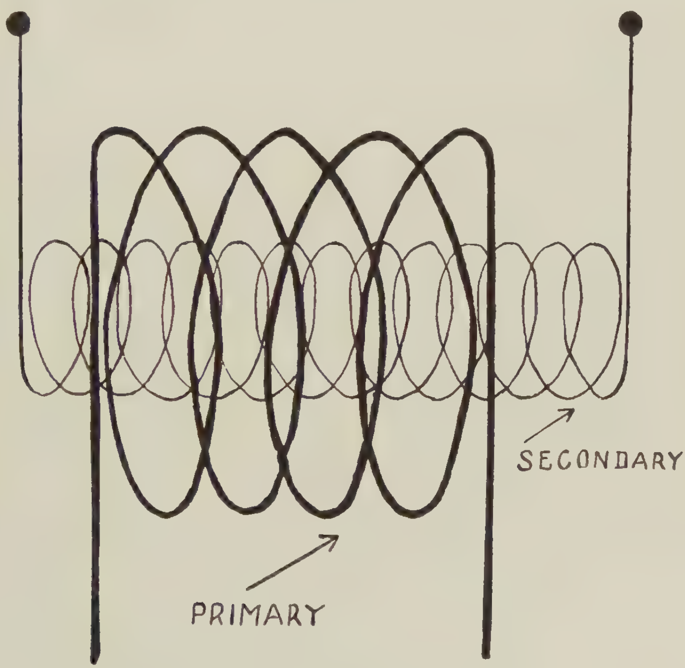

Fig. 19
Diagram Showing One Method of Constructing a Tesla Coil.

As the primary coil is energized by the current from the d'Arsonval solenoid it throws out lines of force which induces a current of very much higher voltage in the secondary coil, just as it does in any other transformer, the increase in voltage depending upon the ratio of turns in the secondary as compared to those in the primary.

Let us now consider the source and character of current delivered by the Tesla coil. Starting with a low voltage, low frequency street current, we build up the voltage in the d'Arsonval transformer, then greatly increase the frequency by the use of condenser and spark gap which energizes the solenoid with a high frequency current of comparatively low voltage and high amperage.

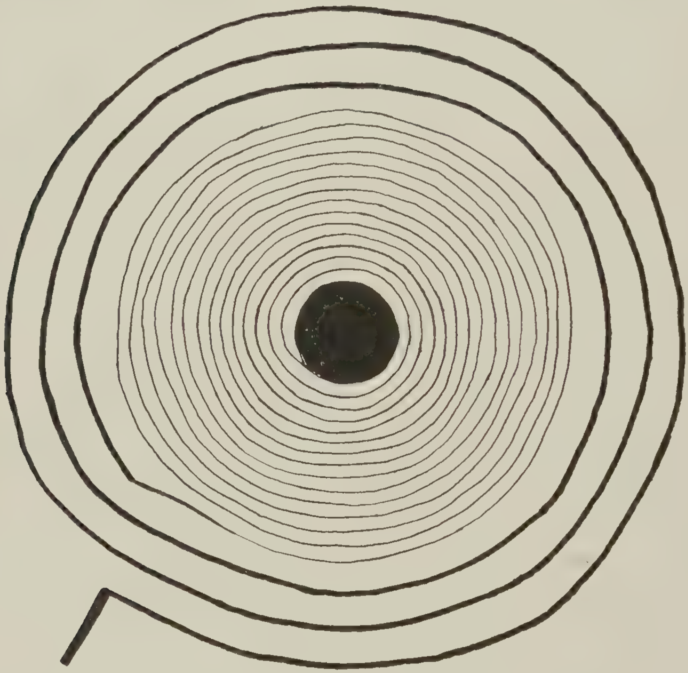

Fig. 20

Oudin Resonator. The Primary Consists of a Few Widely Spaced Turns of Coarse Wire Attached at One End to the d'Arsonval Solenoid and at the Other End Being Continuous with the Fine, Closely Spaced Wire of the Secondary Coil. The Patient's Terminal Is Attached to the Center of the Secondary.

This current is then "stepped up" to a very much higher voltage by the action of the Tesla coil (think of it as a transformer) and as the voltage is so tremendously increased the amperage is necessarily reduced, *as voltage goes up amperage comes down and vice versa.*

The cheap, so-called, "violet-ray" machines do not contain d'Arsonval solenoids, but consist of a low wattage transformer, condenser of small capacity, spark gap (frequently stationary) and

a small Tesla coil. They furnish not a true high frequency, but an interrupted high tension current which is intensely irritating and absolutely unfitted for sedative treatment. If pronounced counter-irritation is desired they may serve the purpose and that is about the limit of their worth.

Production of Oudin Current. The Oudin resonator consists of a series of concentric windings upon the same plane, like a coiled watch spring. (Fig. 20.) The primary winding is made up of a few turns of coarse wire spaced further apart than those of the secondary, which is of fine wire lightly insulated, the consecutive turns of which almost touch and form the center of the coil. The outer end of the primary is connected to the d'Arsonval solenoid, its inner end to the outer end of the secondary, while the inner end of the secondary, which is in the center of the coil, is connected to the patient's circuit.

The high voltage circuit of the secondary coil is induced by the energized primary, just as the Tesla coil or any other transformer, but due to the method and closeness of winding delivers a smoother, less irritating circuit. It is of the same frequency as from the diathermic circuit from which it originated, but of much lower amperage and much higher voltage. *Its application is always mono-polar.*

Properties of the Diathermia Current.

The diathermia current as applied to the patient by two poles is a heat producing modality, and as far as we know, nothing more. The heat so produced is Conversive, i. e. produced *within the tissues* as the result of their resistance to the passage of the electric current. The heat is generated in the tissues in proportion to the square of the amperage used and their resistance to the passage of the current. But in order to meet this resistance, it must go through the tissues, and in order to go through the tissues, it must be a genuine high frequency current—and not a low voltage, low frequency current.

From the previous explanation, it will be seen that a high frequency appliance must be perfectly balanced, that the trans-

former must be large enough to deliver a high voltage current in sufficient quantities to the condenser, which in turn must be of sufficient capacity to store it. The condenser charge must be of such high voltage that the current will break down the air gap and that the electrical oscillations will be of a frequency of approximately two million per second. All this must be possible while the patient is included in the circuit. If the transformer does not deliver high voltage electricity and the condenser have sufficient capacity to store the charges with the patient in the circuit, the electrical oscillations will necessarily be slower on account of the low voltage and instead of the patient receiving a diathermia current absolutely devoid of pain or unpleasant sensations, he receives an interrupted high tension current giving faradic sensations and producing irritation instead of sedation.

Given the choice of two paths, a high frequency current will take the one lying directly between the two electrodes. If the current has not sufficient potential to *force it through* the tissues in the direct path, it will shunt around the part and follow tissues of low resistance, which are the ones heated; usually the superficial.

In passing through a substance between two electrodes of equal size and shape the diathermia current (of sufficient voltage) will gradually heat the tissues in its path. The point of greatest heat will be mid-way between the two electrodes and as the current continues the heated area will gradually expand in all directions. If a glass tube, closed at each end by corks, each being pierced by a short piece of copper wire, is filled with egg albumen and the d'Arsonval current connected to each copper wire terminal the passage of the current will coagulate the albumen in the tube mid-way between the two terminals, and as the heat becomes more intense the heated area will increase until finally the entire mass of albumen is coagulated. If a low voltage current is used, or a high milliamperage is suddenly switched on, the coagulation will take place first at each end of the tube around the copper terminals.

By changing the relative size of diathermia electrodes, heat may be localized in the tissues as desired. (Fig. 21.) In Endothermy or

Surgical Diathermia, destructive heat is produced by using a metallic point, as a needle, as one electrode; in which case the path of the current converges from the large electrode to the needle point under which sufficient heat is concentrated to coagulate and burn the tissues.

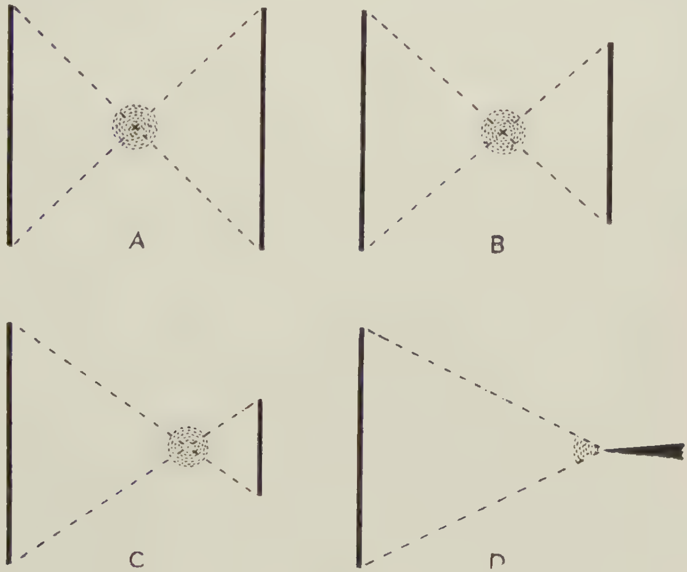

Fig. 21

Showing Area of Greatest Heat with Reference to Relative Size of Electrodes.

Heat produced in living tissue varies as the resistance, consequently bone offering the greatest resistance heats slowest and retains its heat longest, fat is of high resistance, fibrous, scar and callus tissue have a high resistance, but on account of their scanty blood supply heat up faster than normal tissue and retain the heat longer. Dry skin has a high resistance. Tissues having a high vascularity heat quickly but as the blood stream constantly carries away the heat from the part, do not long retain it. The blood itself heats less, as it offers slight resistance to the passage of the diathermia current.

This dissemination of heat by the blood stream is demonstrated in an experiment by Cumberbatch in which a patient received 400

milliamperes of diathermia through metal electrodes held in each hand for twenty minutes. There was a rise of temperature (Fahrenheit) in the front of the wrists of 6°, front of elbow 4°, axilla 2.4°, mouth 2.6°, groin 1.2° and popliteal space 3°. The increase of temperature in the wrists, elbows and axillae was due to the actual

Fig. 22
Folding Auto-Condensation Pad.

heating of tissue by the passage of the current, while the rise of temperature in the mouth and leg was due to the heating of the blood stream.

Physiological Action of High Frequency Currents.

General.

While the treatment of general pathalogical conditions does not fall within the province of the chiropodist, yet the systemic effects produced by the high frequency currents should be understood as well as the method of application. The method used to flood the entire body with high frequency impulses is known as **auto-condensation,** in which the patient is placed upon a chair or table covered with an insulating pad consisting of a sheet of metal separated from the patient by a *di-electric,* or layer of insulating material, sufficient to prevent the direct passage of electricity from the metal to the patient. The metal plate is connected to one pole

of the d'Arsonval or Tesla coil. The other pole is attached to a metal tube or cylindrical electrode in the hands of the patient. (Fig. 22.)

With the patient in position the arrangement is the same as that of a Leyden jar, in which the sheet metal of the pad corresponds to the inner metallic coating of the jar, the insulating material of the pad to the di-electric or glass, and the patient to the outer metallic coating of the jar.

As the circuit is closed, the metal pad is charged, let us say, positively. Immediately the patient receives a negative charge by induction, and as the polarity rapidly changes with the oscillations of the high frequency current, the tissues of the patient's body are successively of one polarity and then the other. No current actually passes through the condensation pad and yet the milliameter registers a flow of current, which the patient experiences in the form of a warmth or heat, especially noticeable in the arms.

A better application is obtained if the hand electrode is replaced by a large square or oblong block tin electrode, laid smoothly upon the abdomen and held firmly by a few turns of bandage or weighted with a sand bag. In this way, the current passes more generally through the body and not by way of the hands and arms. When the hand electrode is used a pillow should be placed between the arms and the body to prevent short circuiting and unpleasant sensations of sparking.

Both the d'Arsonval and Tesla currents are used in auto-condensation but inasmuch as the Tesla current is of higher voltage and lower amperage, it is better suited to general body treatment than the low voltage, high amperage diathermia current. When the latter mode is used, a greater heat is generated within the tissues and a larger dosage is required, usually from 1200 to 1500 milliamperes is required. While with the high voltage Tesla current, a milliamperage of 300 to 900 is sufficient.

When the appliance used furnishes a d'Arsonval combined with an Oudin current, the voltage may be raised by removing one of

the conducting cords from the d'Arsonval outlet and inserting it in the Oudin outlet.

The systemic effect of high frequency oscillation upon tissues is that of a cellular massage resulting in a mild stimulation of the processes of metabolism, especially those of elimination. Thus it is indicated in all forms of toxemia, as well as the elimination of broken down tissue following inflammatory changes, inflammatory exudates, etc. Body heat is gradually increased as evidenced by the thermometer reading, the pulse is quickened and a soothing sense of rest, drowsiness and relaxation is experienced. Systolic blood pressure is lowered.

Auto condensation should be applied gradually and with caution in cases exhibiting a very high or a very low blood pressure, as well as an arteriosclerosis. In the latter condition, the current from a d'Arsonval outfit is indicated rather than Tesla auto-condensation on account of the greater heat produced and its softening effect upon the sclerosed tissue.

Local Action of Diathermia.

When diathermia is applied to the body the first effect is generation of heat in the tissues through which the current passes. This heat is greatest in the areas of highest resistance, but is present in all the tissues. It is *conversive* heat, produced by conversion of electrical units into heat units through the resistance offered by the tissues.

The heat thus produced causes an active arterial hyperemia, bringing more blood to the part and consequently causing more venous blood and lymph, loaded with waste tissue products, to flow away from the part. In other words, an artificial inflammation has been produced.

Inflammation is a complicated vascular and cellular response to bacterial or traumatic injury, bringing much blood to the part and pouring out its elements upon the injured or diseased tissues, to prevent the extension of the injury, hold in check the injurious agent or even destroy it. Through the agency of some of the cells which are brought in, and in other ways, it is also important in

clearing away the debris of injured or dead tissue and preparing the way for the process of repair.

The cardinal symptoms of inflammation are heat, redness, swelling, pain and loss of function. Of these, the most significant *is heat.* Pain is merely an incident—being caused either by the original injury or by pressure as the tissues become swollen or infiltrated. Loss of function is due either to the injury causing the inflammation or an effort upon the part of nature to enforce rest, or immobilize the tissues. Thus we find that there are three essential symptoms of inflammation, viz. heat, redness and swelling. The former produces the latter, for as warm blood is brought to the part, the temperature necessarily rises and is further increased by oxidation of waste material; while the heightened blood supply results in an infiltration of the tissues and swelling. Redness is incidental to the heat and produced by the congestion of superficial capillary vessels.

In commenting upon the use of heat in the treatment of infections, Crile makes the following assertion: "In what way may heat exert its beneficial influence? Granting the premise that the natural defense of the organism against infection is made through the agency of phagocytosis and the chemical antagonism of the blood plasma, it becomes evident that in either case the defense is chemical. The fact that the defense is chemical gives at once a clue to the mechanism by which heat assists the defense against bacteria. It is probably because with the rise of each degree in temperature in any system, inorganic or biologic, the chemical activity is increased 10 percent and the electric conductivity 2½ percent. The increased chemical activity increases the chemical defense; the increased electrical inductance increases the metabolism. Therefore we may suppose that heat accelerates the chemical defense as far as it involves the metabolism of the phagocyte, and as far as it involves a chemical defense of the blood pressure and that heat aids also by increasing the total amount of blood in the inflammed part, thereby increasing the number of phagocytes. Moreover, heat assuages pain."

Thus the generation of heat within the tissues not only acts to mechanically enlarge the calibre of the arterioles, permitting more blood to enter the part and by so doing increasing the ability of the tissues to defend themselves against infectious processes, but by dilating the vessel walls, encourages the passages of lymph, rich in repair material, to pass into and nourish the tissues. Meanwhile the increased local temperature relaxes muscular spasm and exerts a liquefying and softening effect upon fibroses and exudates, making it easier to break them up under massage or vibration and expedite their absorption.

Pain is relieved by the direct influence of heat upon the nerve terminals as well as by the relief of pressure as the result of the absorption of exudates.

The physiological action of local diathermia is directly proportional to the amount of heat produced, which is *cumulative,* i. e. accumulates within the part, becoming intensified as the application is continued.

Local Action of the Tesla and Oudin Currents.

The Tesla and Oudin currents are applied in chiropodial work by attaching a glass condenser electrode to *one* conducting cord leading to the designated outlet upon the machine, consequently they are *mono-polar* currents (The Tesla current may be used bipolar, but its use in this way does not compare with the results obtained by the bi-polar d'Arsonval current in leg and foot work, consequently it has not been considered in this treatise).

When the electrode is placed upon the skin, heat is produced in the superficial tissues under it (the depth of penetration depending upon the strength of the current) which permeates the entire body, oscillating to and fro with each oscillation of the current in the electrode and passing off into the air from the entire surface of the body. This may be demonstrated by holding a second condenser electrode near the surface at any point, which will be illuminated by the high frequency impulses discharged from the charged body. Two distinct results may be obtained by the local use of these currents, first a *sedative* effect produced by

a low milliamperage, in which there is a gentle heating of the skin, dilitation of the superficial capillaries, stimulation of the skin glands and increased local metabolism. Pain and sensitiveness is relieved by the action of the rapid oscillations upon the sensory nerve endings and the sedative action of uniform heating of the parts. The penetration of heat ranges from a small fraction of an inch to two inches, depending upon the amount of current used and the type of condenser electrode. The heat produced in the tissues by this method is essentially surface heat and does not exist deep in the tissues as does that found between the two poles of the diathermia current. However, it is cumulative and where a strong current is used, it is necessary to move the electrode about as the underlying tissues become over-heated.

The second effect obtained by condenser electrode applications is that of *stimulation*, in which a current strong enough to throw a spark of from one quarter to one half inch is used and the electrode alternately touched to the skin and withdrawn, causing a shower of sparks or effluve to pass between it and the skin. This furnishes a potent means of stimulating terminal nerve endings in various sensory disturbances, anaesthetic areas, etc. Used upon a skin reddened by the sedative technic, it will cause blanching of the hyperemic area as the result of stimulating the vaso-constrictor nerves. Muscle tire and fatigue is relieved by the stimulative action of these currents upon the nerves and the increased local metabolism produced by the application of superficial heat. Actual counter-irritation may be produced by the use of long sparks played over the part. When used with a pointed metallic electrode or needle, and a quarter of an inch spark, the mono-polar Tesla current will burn a tissue upon which the spark is thrown. This is accomplished by the intense heat concentrated at the point of the needle and is known as *fulguration*. The mono-polar Oudin current used in the same manner with the needle point touching or inserted in the tissues, dessicates, dries and devitalizes the tissues. The dessicating spark is not hot enough to carbonize, but is of sufficient heat to cause rapid dehydration of the tissue,

rupturing the cell capsules and converting the area into a dry mass. This is known as *dessication* or mono-polar endothermy and must not be confused with fulguration or tissue coagulation. (Fig. 23.)

Therapeutics.

The high frequency currents have a wide range of use in treating diseases and deformities of the leg and foot and if scientifically applied will accomplish results not obtainable in any other way.

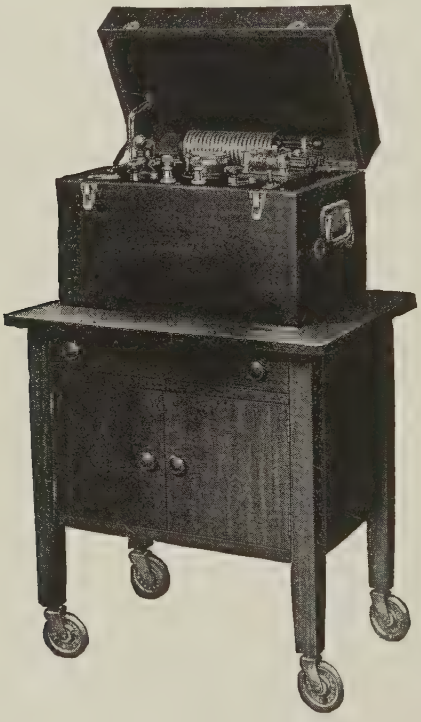

Fig. 23
Portable Diathermia Apparatus with Mono-Polar Tesla Current.

The conversive heat of diathermia is energy converted into heat in the tissues themselves and heat, as we have previously considered, is the essential symptom of inflammation, which in turn is nature's response, or reaction, to injury, be it infectious or traumatic. Consequently, diathermia is applicable in both acute and chronic conditions. In acute conditions, its action is to relieve

inflammation, pain and swelling, to assist in the absorption of exudates and inflammatory debris, and increase local nutrition. In chronic cases, it relaxes muscular spasm and tissues in which a fibrosis exists as the result of a proceeding inflammatory process. It is a softening, liquefying agent, not on account of any electrical properties, but due to the heat generated in the tissues by the passage of electricity.

The pain, inflammation and swelling of acute bursitis, tendo-synovitis and synovitis, as well as acute sprains, indicate the use of conversive heat to restore the arterial circulation, absorb the fluid distending the synovial membranes and prevent fibrous thickening of the diseased tissues.

The ability to heat a joint through-and-through producing a deep and positive hyperemia places diathermia in a class by itself in the treatment of arthritis irrespective of the joint involved or the cause. Traumatic or toxic, conversive heat is the remedy, the only exception being those cases in which pus is bottled up in the joint, or where there is a breaking down of joint structure as tuberculous arthritis. After drainage has been secured, diathermia may be used with safety.

In either the traumatic or infection type of acute neuritis diathermia is capable of producing heat not only throughout the entire path of the nerve, but within the inflammed nerve tissue. Chronic cases exhibiting connective tissue changes in and about the nerve trunks demand the softening action of heat and diathermia is the rational agent.

Neuralgic pain often responds to sedative diathermia and while it is but a symptom of an underlying condition, yet the warming up of a painful nerve often relieves the distress. The pain occurring during a paroxysm of Morton's Neuralgia is quickly relieved by diathermia. However such cases are seldom seen at the time of paroxysm, but the use of diathermia throughout entire course of the nerves supplying the lesser toes, combined with the rapid or rapid interrupted sinusoidal is indicated as routine treatment in these cases and attended with good results.

In subacute and chronic conditions of all sorts found in the leg and foot diathermia is indicated to relax, soften and hasten the absorption of fibrous tissue formation which always follows inflammatory processes as well as traumatism. No matter what the character of the tissue may be, the indications are the same, namely, to increase the process of local waste and repair by supplying increased blood to the part, to soften or liquefy the fibrosed tissues and make its absorption by the blood and lymph streams possible.

Thickened synovial or bursal tissue; fibrosed, rigid and ankylosed joints; nerves and blood vessels the structure of which is changed by connective tissue deposits; irritable contracted muscle tissue due either to injury, improper attitudes or overwork; atrophied and atonic muscles as the result of non-use or nutritive changes; all these chronic conditions are amenable to the action of conversive heat intelligently applied.

For the more superficial acute conditions the application of a mild Tesla or Oudin current, by means of condenser electrodes, is indicated in chiropody. These include inflammatory conditions about the toes resulting from pressure, as inflammed and infected corns; acute bunions; onychia and paronychia; disturbances of the sensory nerves as evidenced by morbid sensory impressions about the toes and upon the dorsum of the foot; skin lesions; fissures; ulcers; chilblains and cold extremities.

The heat produced by a stronger Tesla or Oudin current and condenser electrode will be sufficient to accomplish superficial heating of the foot and leg when diathermia is not available or practical. Heat thus produced is indicated to soften contracted muscles, while a lesser degree applied over weakened and relaxed muscles, as in the anterior muscles in weak-foot and flat-foot, will relieve tire and restore tone by increasing the blood and stimulating the nerve supply.

For the destruction of small growths upon the foot, as verrucae, papillomata, naevi, fibrous tumors, vascular or nervo-vascular corns, etc., no method will compare with Endothermy or Surgical Diathermia, or the mono-polar Oudin method known as Dessica-

tion. The wounds produced by these currents are sterile, the blood vessels and lymphatics seared off or dried to the point where infection is almost impossible.

CONTRAINDICATIONS. The use of diathermia is contraindicated over a site of recent hemorrhage, due to the fact that this current will distend the blood vessels by bringing an increased supply of blood to the part and increase the liability to hemorrhage.

Again, it should not be used over a pus cavity or in tissues which are breaking up as the result of toxic infection, unless drainage has been established. The absorption of bacteria, pus or septic matter might be hastened by the action of this current upon the blood vessels and lymphatics, and cause general infection.

Diathermia Technic.

Success or failure in the practice of Diathermia depends upon a high frequency machine of capacity and balance, proper selection and application of electrodes, and scientific current control. Attention to the slightest detail is absolutely necessary if good results are expected.

Current Control. The alternating street current is, naturally, of too high amperage to be used for treatment, consequently every high frequency appliance contains some form of control mechanism for limiting the current entering the machine. These consist of either a rheostat, choke coil, auto-transformer or variable resistance coils placed in the primary circuit.

After the patient is placed in a comfortable position, the electrodes applied and all connections inspected as well as the meter needle adjusted to the exact zero point, the "off and on" switch connecting the machine with the street main is thrown to "on." The selective switch, rheostat or other device furnished for the regulation of the street current is then opened slightly or to its lowest control point.

Spark Gap.

As has been previously explained, the spark gap is a variable resistance placed in the circuit of a high frequency appliance to

force the high voltage current received from the secondary coil of the transformer to back up, or fill the condenser and when the current stored in the condenser is of sufficient voltage, it jumps across the spark gap to neutralize the opposite charge upon the outside of the condenser and then oscillates back and forth until the particular condenser charge is exhausted.

When the spark gap is opened, that is, when the distance between its points is increased, it will necessarily require a higher voltage to jump across the widened space and when this is accomplished, the rapidity of the oscillations back and forth will be increased in proportion to the intensity of the condenser discharge. In other words, the spark gap is *a throttle or voltage control* and upon its action depends the character and frequency of the oscillations received by the patient.

If a spark gap is allowed to become dirty or the joints to oxidize or corrode, a lower voltage will be required to jump the gap than when it is clear and clean, and consequently the oscillations will be uneven and irregular and the patient will receive a low voltage, low frequency current which will not only be irritating and faradic, but lack the power to drive the current through dense resistance.

The action of the spark gap and its proper care being understood, we now return to the technic of current manipulation. We will assume that we are treating an ankylosed ankle joint and from the size of the electrodes used we expect to generate 500 milliamperes within the part.

The rheostat switch being upon its lowest point, the spark gap is slowly opened until the meter will show that about 50 milliamperes of current is passing between the electrodes. This current is held for half a minute when the spark gap is open a little wider causing the meter to show a higher reading, 75 or possibly 100 ma. This is continued for a short time when the gap is still further opened. Meanwhile the sparks flow evenly across the gap, making a regular, soft, frying sound. When the point is reached where the sparks become irregular and sputtering, close the spark gap

and turn the rheostat control or selective switch to Number 2 point, allowing a stronger current to flow into the machine from the street main.

Again open the spark gap slowly until the meter needle reaches the point previously occupied. A different sound is now emitted by the spark gap; it is regular and smooth, but of greater intensity and volume, for the condenser is charging faster and a greater volume of current is being discharged.

Open your spark gap little by little during the next minute until you have reached, possibly, 300 or 400 ma. of current. If your machine begins to sputter and produce irregular sparks, close the gap, throw your rheostat to the next control point, open the gap and build up your milliamperage to the point where you left off and then gradually increase it through the spark gap control until you have reached your ultimate goal of 500 ma. No exact rule can be laid down for the manipulation of current and spark gap control due to the difference in capacity of various machines, or for that matter, in machines of the same type, but the above mentioned milliamperage is approximately that obtained in such a resistance area by the average portable diathermia outfit.

The essential points to be remembered are, that the milliamperage must be *increased gradually*, that no more current should be taken into the machine through the rheostat control than the spark gap control can convert into rhythmic, uniform high frequency oscillations which are within the patient's tolerance. If the machine is receiving a heavy charging current from the street main and the spark gap is but slightly open, you will be delivering a current of high milliamperage and low voltage for the spark gap is the voltage throttle and you are not opening it sufficiently.

Never turn the current on or off or change the controls regulating the passage of the current into the transformer without closing the spark gap. Increase milliamperage gradually and through progressive control steps; too quick or too much heat results in unpleasant heating and faradic sensations as well as

setting up skin resistance and reflex action in the tissues, antagonistic to the formation of heat.

Sedative and Stimulative Technic. Current technic is most important in the application of diathermia. A **sedative** action is obtained by gradually increasing the current to the degree of heat desired, which should consume from 3 to 5 minutes, holding the current at this point for a period of from 15 to 20 minutes, or longer, if desired, and then gradually decreasing the milliamperage over a period of from 2 to 3 minutes. Progressive stepping up of the current prevents increased skin resistance and reflex action which antagonizes free passage of the current uniform heat production. Sedative technic is indicated in all cases requiring high heat and deep hyperemia. The existence of effusious, muscular spasm, acute and chronic inflammation processes, fibrositic changes, painful conditions, in fact practically every condition arising in chiropodial practice will demand sedative diathermia, and this technic is invariably the one referred to in discussing the subject of diathermia in this book unless the stimulative technic is specified.

Stimulative diathermia is obtained by abruptly running the current up to the maximum heat intensity, holding it at this point from 5 to 10 minutes and then suddenly turning it off. This technic is used only in cases when a decided reaction is required, as in sluggish tissues, non-union of fractures, etc.

Dosage. In the administration of the diathermia current the sensation and tolerance of the patient is the most accurate guide; granting that the electrodes are of the proper size and shape and that their application to the part is perfect, nevertheless different individuals will accept different degrees of heat. In many cases an element of fear or nervousness prevents the use of ordinary milliamperage. As the confidence of the patient is secured and the effects of the current understood, a higher dosage may generally be given. However, there are cases in which the meter reading must be considered rather than the patient's sensations,

as those exhibiting areas of anaesthesia or lessened sensation. Diathermia in such cases, as well as those of arterio-sclerosis, must be used with extreme caution. In the latter condition, the sluggish circulation does not carry away the heat as in normal vessels, while the inelastic arteries are severally taxed by the increased blood stream. A dusky erythema under the electrodes is a warning that the current strength must be reduced in following treatments.

Thus the milliameter, the patient's sensations as well as the appearance of the treated tissues must all be observed as guides to dosage.

Three general rules are to be applied in the use of diathermia. The first is that the density of the dosage depends upon the area or size of the *active or smaller electrode* (the electrode placed over the point where greatest heat is desired). For instance, if one electrode is 5 inches square and the other 10 inches. The first has an area of 25 square inches, the second 100 square inches, or four times the area of the first. If 1,000 ma. of current is being given each of the 25 square inches of the smaller electrode carries 40 ma. and each of the 100 square inches of the larger electrode carries 10 ma. Thus the small electrode is carrying four times the current of the larger and the heat developed under it will be four times as great.

The maximum dose employed should not be over 100 milliamperes per square inch of the surface area of the *smallest* or active electrode. For an example, a piece of block tin 2x4 inches contains 8 square inches and consequently not more than 800 ma. of current should be used with an electrode of this size. Dosage is also dependent upon the character of tissues treated, their depth and density. As a matter of fact it is safe, as well as more satisfactory in foot work, to use a dosage of from 50 to 75 ma. per square inch of electrode surface. It is also advisable to use as large electrodes as can be applied to the part without wrinkling or creasing.

Second. The heat produced in the tissues by Diathermia varies as the square of the amperage. For example, if you are giving 200 ma. and increase the current to 400 ma. you will not produce twice as much heat as you did at first, but rather the *square of the increase* (2x2) or four times as much. If you ran the current up to 600 ma. you would not be giving three times the heat you did at first, but the square of three (3x3) or nine times the heat.

Third. The heat formed in a given part by the passage of a given amount of current *varies as the resistance* encountered. The tissues having the greatest resistance will generate the most heat and hold it the longest.

Electrodes. The best electrode material consists of Crook's metal or block tin of from eighteen to twenty-six gauge. Twenty-two gauge is the thickness most generally used in foot work, but eighteen gauge, being thicker is frequently used for electrodes that are to be applied to broad or uniform surfaces, as the calf of the leg. Twenty-six gauge is quite thin and capable of being moulded over small, prominent surfaces as the great toe and phalangeal joints—however, in such cases it is surpassed by the flexible mesh material.

Block tin may be cut in any shape desired with a small flap projecting from one side to which the conducting cord can be clipped. The electrode should be smoothed out by a roller, a pencil will answer, so that no wrinkles are present and all corners and sharp edges should be rounded by scraping with a knife or piece of fine sand paper. High frequency currents try to leave an electrode by sharp edges and corners and if sparking and unpleasant sensations are to be avoided, electrodes must be smooth, with rounded edges and corners. The edges of block tin electrodes may be folded over one-quarter of an inch giving a rounded margin, but this is inclined to stiffen the electrode and make it more difficult to mould to the part; consequently for foot and leg use an electrode with well rounded edges and corners is preferable. Gen-

erally speaking, electrodes to be used upon the lower extremity should be oblong in shape, rather than square or circular. (Fig. 24.)

Cuff electrodes, of twenty-two gauge block tin, which encircle the limb are invaluable in foot and leg treatments and are used when it is desired to include a large area in the heat zone, but upon the leg, should not be used closer together than six inches. The heat generated between two cuffs placed upon a limb, one above

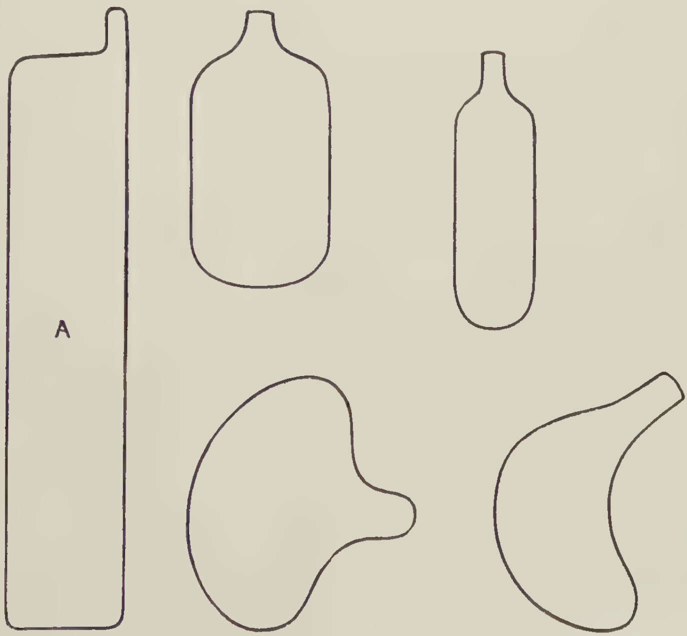

Fig. 24
Diagram of Block Tin Electrodes Adapted to the Foot and Leg.
A—Cuff Electrode.

the other, will of necessity extend through the more superficial tissues, and not through and through the limb as it would if one plate was placed upon one side of the limb and another upon the opposite surface. Cuff electrodes are usually two inches wide and fifteen to eighteen inches long, with a flap either at one corner or near the center for the attachment of a clip. These are wrapped smoothly about the leg and bound firmly, but not tightly,

in place with a few turns of elastic bandage. In computing the dosage used with a cuff electrode only the actual circumference of the limb is considered. Any overlapping of the cuff is to be disregarded. In clipping electrodes or cuffs to conductor cords the electrode farthest from the body should be clipped upon its distal edge and the one nearest the body upon its proximal edge. (Fig. 25.) The exact point upon the edge to which the clip is to

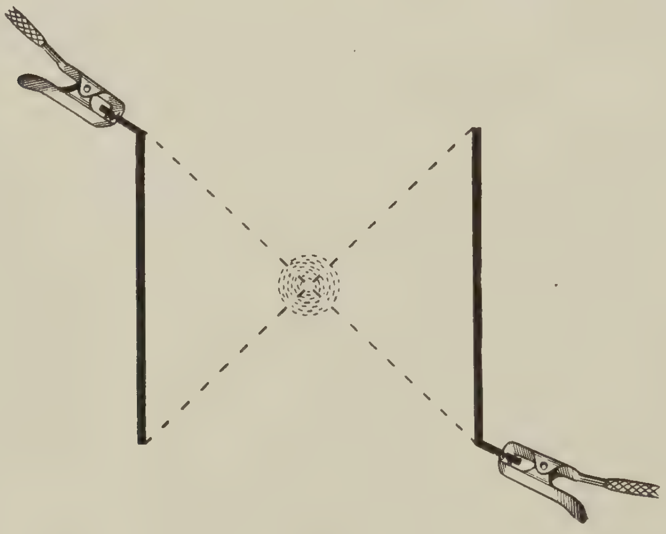

Fig. 25

Showing Correct Position and Method of Attaching Clips to Electrodes.

be attached depends upon the desired localization of the heat. As a general working rule we may consider the greatest area of heat to exist along a line drawn from one conductor clip to the other.

Flexible metal mesh (Figure 26) is also used as electrodes in diathermia and afford a method of securing close adaptation to uneven and bony surfaces. When laid upon a part it closely conforms to its contour and makes a good contact. It may be cut to fit and is especially serviceable in applying diathermia to the dorsum of the toes, first and fifth metatarso-phalangeal joints and the dorsum of the foot. If but little traction is put upon it by the conductor cord it is not necessary to bandage it in place. In

using flexible mesh it is always advisable to place a piece of oiled silk or rubber dental dam over it to prevent evaporation of moisture through the meshes, otherwise the moisture of the skin will dry out and a poor contact ensue.

Fig. 26
Flexible Mesh.

The use of electrodes made of absorbent material wet with a saline solution is not good practice. These dry out under long application, again, the water gravitates to the lowest point of the pad resulting in uneven distribution of the current and localization of heat—even to the point of blistering.

Electrodes consisting of pads of rubber sponge around which is wrapped flexible mesh are used upon uneven and bony surfaces with good results. (Fig. 27.) These may be held in place by a bandage or when used upon the knee or ankle retained by a wooden clamp as shown in the illustration. When such a clamp is used much care should be exercised in its adjustment and the electrodes closely watched during the treatment that they do not become displaced.

A salt solution, in which a part is partially or wholly immersed, may replace one metallic electrode. In treating the extremities this is an ideal arrangement and as the contact is perfect by exercising a little ingenuity a variable area may be brought in contact with the electrolyte, which acts as an electrode. A shallow pan or tray, made of glass, earthenware, hard rubber or porcelain covered metal is used to contain the warm salt solution and one conducting cord from the d'Arsonval apparatus is clipped to a strip of block tin, six inches long, which is bent to hang over the tray and rest

upon its bottom. The foot being placed in the solution a block tin electrode is bound upon the leg, ankle or exposed portion of the foot, depending upon the area and location to be treated, and clipped to the other conducting cord. When the current is switched on it flows through the water, which is a good conductor, and the

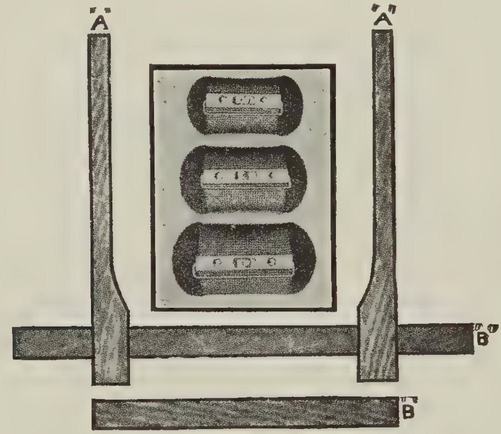

Fig. 27

Rubber Sponge and Flexible Mesh Electrodes,
Used in Diathermia, with Wooden Clamps.

tissues to the metal electrode, thus completing the circuit, and in proportion to the resistance encountered heats the tissues.

If a metal tray covered with porcelain is used care should be taken that no part of the foot or ankle, not covered with water, touches the tray, for the average porcelain is not always a perfect insulator and a disagreeable shock or burn might result. Where there is a possibility of the skin touching the tray it is well to cover it with a bit of rubber dam, as well as place rubber dam under the block tin strip when it bends over the edge of the vessel.

Application of Electrodes. Before applying electrodes the skin, if very oily, should be cleansed with alcohol and if a heavy growth of hair exists it should be removed, as it prevents good contact. The block tin electrodes, smooth, with well rounded edges and corners, are covered with soap lather, as well as the surface to which they are to be applied, and placed in position, securing them firmly, but not tightly, with a *few turns of woven elastic bandage.*

The use of ordinary muslin or gauze bandages is contraindicated on account of their inelasticity, which does not allow them to stretch as the part expands as a result of the hyperemia produced by the conversive heat. If such bandages were used, as the tissues swelled they would cut off the venous circulation and produce a venous hyperemia or stagnation, which would be just the opposite of the desired arterial hyperemia: or the constriction might in a protracted treatment cut off the arterial circulation and produce an ischemia. In any event the particular results so greatly desired might be prevented. If very small electrodes are used, they may be covered with sheet rubber and held in place by adhesive plaster strips.

Soap lather is used upon the skin to soften and remove part of its outer horny layer which offers considerable resistance to the passage of electricity, as well as to secure a good contact. After a few minutes of diathermia sufficient perspiration will collect under the electrode to maintain good conductivity. In applying flexible mesh electrodes soap lather should be freely used and a covering of rubber dam applied to prevent the evaporation which takes place through the interstices of the mesh.

In using plate electrodes upon opposite sides of the leg or foot it will be found better to make them long and narrow rather than short and wide. When it is desired to localize the heat near one surface use electrodes of unequal size (Fig. 21) and place the smaller over the surface to be heated. The smaller the electrode the closer will be the heated area to the skin, and the greater the danger of coagulating the tissues if a high amperage is used. Remember that the strength of the current is based upon the *area of the smaller electrode.* Use 50 to 75 ma. for each square inch of surface: not more than 100 ma. in any event. Surgical diathermy or Endothermy is ordinary diathermia in which a needle point takes the place of a large plate electrode, thus concentrating extreme heat in the tissues immediately beneath it.

In the application of double plates to secure through and through heat it is of the utmost importance that they lay nearly

flat upon the surface and about the same distance from each other throughout their extent. If their edges are much closer together than their centers the current will pass from edge to edge through the intervening tissue rather than through the more dense tissues of higher resistance, laying between the body of the plates.

In applying plates over dense tissues and high resistance areas, as the knee, ankle or tarsus, remember that the heat varies as the square of the amperage and that a slight increase in your meter reading means a much greater increase of heat within the tissues. Again, heat produced within the tissues varies as the resistance.

In using cuff electrodes the superficial tissues develop the greatest heat. Experiments have shown that when two electrodes are placed side by side or end to end, the hottest point is on the skin between them. Two electrodes placed upon the back of the forearm, the edges parallel and one inch apart, showed an increase of eight degrees of temperature under the center of the plates and twenty-one degrees under the edge facing the opposite electrode. When the foot is placed in a bath, or upon a foot plate, and a cuff electrode is fastened upon the leg the area of heat will be greatest when the leg tapers to meet the ankle, for the reason that this part of the limb is smaller than the foot and leg and that the current passes through a constricted area.

By regulating the depth of salt solution in a foot bath, the location of the terminal in the tray and the position of the foot almost any portion of it may be heated by diathermia. A very little saline (¼ or ½ inch) will serve the same purpose as a perfect fitting foot plate, bringing the current through the superficial plantar tissues; an inch of solution will include more tissue in the circuit, while if the entire foot is covered a general distribution of the current will be obtained, with the line of greatest intensity between the terminal and the opposite electrode.

The diathermia current will enter that part of the foot nearest the distal electrode and, if of sufficient voltage, take the most direct path to the other electrode. This being the case it can readily be seen that the distal electrode should be so placed in the

tray, in reference to the foot, that the current will mainly traverse those tissues in which heat is desired. Placing the toes in the solution, or the ball of the foot, or the heel, or tilting the foot so that one border only is immersed, will localize the heat between the immersed part and the other electrode. A simple device (Fig. 28) consisting of a piece of board 4x12x7/8 inches, beveled on the flat may be inclined within a tray in such a manner that the foot may rest upon the board without tiring the patient. If grooves are cut in the board upon its under side it will fit over the edge of the tray and rest more secure.

Fig. 28
Wooden Rest Used to Incline Foot in Foot Bath.

Direct application of two metal electrodes will produce a greater heat within the tissues than the combination of one metal plate and a saline solution in which the foot and the other electrode is suspended. However the heat produced by the latter method is usually quite satisfactory and when the density of the tissues of the foot is considered as well as the difficulty in securing close electrode opposition it may be said to be a safer mode of application when it is desired to limit heat to the foot.

Regional Technic.

Toes. The best method of applying diathermia to the toes is by immersing them in a tray of salt solution in which an electrode is placed nearest the toe, or toes, to be treated. This may easily be done by using the inclined foot rest just described, or the patient may recline face down with the toes dropped into a foot bath. The indifferent electrode may be placed upon any part of the foot, ankle or leg, depending upon requirements. A piece of flexible metal mesh laid over the dorsum of the toes will mould itself to the part and make a good contact. Thin tin foil is also used for toe electrodes but is difficult to retain in position.

Metatarsal Region. When it is desirable to produce heat in the region of the metatarso-phalangeal joints and in and about the metatarsal arch the foot may be inclined at such an angle that its ball will rest in one-half an inch of saline solution, which acts as one electrode, and another electrode, oblong in shape (2x3 inches) is bound across the dorsal surface. This may be of block tin or preferably metal mesh. A plate may also be used upon the plantar surface instead of the water bath. Ordinarily both electrodes should be about the same size which will localize heat in and about the joints. The plantar electrode should be attached at its center, nearest the toes, and the dorsal electrode on the edge nearest the ankle. If the entire area supplied by the plantar, posterior tibial and internal popliteal nerves is to be heated the ball of the foot is placed in the tray and a large sponge pad (3x4 inches) covered with mesh is bound upon the upper portion of the calf just below the insertion of the outer and inner hamstrings. Or, if a still greater area is to be treated a block tin plate may be placed upon the ball, or entire sole of the foot, and another upon the posterior surface of the thigh over the great sciatic nerve.

In treating the tissues about the first or fifth metatarso-phalangeal joints, as in arthritis, bunion, hallux rigidus, displaced sesamoids, dancer's toe, etc., the foot may be inclined and tilted, either upon its inner or outer border, with the affected area resting in about one inch of water. The indifferent electrode, preferably of mesh (1½x3 inches) would then be applied upon the opposite border of the foot in the tarsal region. The active electrode may also consist of a small piece of mesh, 1½ inches in diameter, laid smoothly over the joint covered with rubber dam, and held by a few turns of narrow bandage. In this method use low milli-amperage, for the concentration of heat about the joint will be marked.

Tarsal Region. With the outer border of the foot placed in one inch of warm saline solution a block tin or mesh electrode (2x3 inches) may be placed longitudinally upon the inner border of the foot with the terminal clips attached upon its edge nearest

the ankle. The opposite electrode should rest in the water at the outer border of the foot near the base of the fifth metatarsal bone. A foot plate may be used in place of the water with the conductor cord clipped to it in a corresponding position.

Two oblong block tin electrodes ($1\frac{1}{2}$x3 inches) may be applied to the inner and outer border of the tarsus when a direct heating effect is desired in the medio-tarsal joint. Close and smooth opposition should be secured by the use of an evenly applied elastic bandage. This is dense structure, but lightly covered with soft tissue—watch your milliamperage closely.

Ankle Joint. The best method of applying diathermia to the ankle joint is by placing the foot in a bath and encircling the leg, 3 or 4 inches above the ankle, with a cuff electrode two inches wide. At first attach the clip to the upper edge of the front aspect of the cuff and later remove and attach to the upper edge of the cuff behind. By so doing you change the direction of the line of heat or "cross fire" and secure more uniform distribution. (This reversal of connection points may be practiced in almost any arrangement of electrodes.) In binding the cuff upon the leg use just enough tension to hold the cuff in place, do not bandage tightly.

Lateral block tin plates are extremely difficult to adjust upon the ankle and their application for this reason is not good practice. When a through and through distribution of heat is required in the ankle joints it is best secured by the use of rubber sponge pads covered with mesh and either held in position by elastic bandages or wooden clamps. (Fig. 27.)

Leg. When a general distribution of heat is desired in the foot and leg it is best accomplished by using a foot bath, in which one electrode is placed, and a cuff about the upper part of the calf. If it is desired to localize the heat in the leg, as for instance in applying heat for the relaxation of contracted calf muscles, two cuffs (2 inches wide and long enough to encircle the leg) may be used. One above the ankle about 3 inches and the other just below the knee cap; or two block tin plates (3x4 inches) may be bandaged

upon the posterior surface of the leg in the same position. To secure direct heating through the calf muscles two plates (2x4 inches) may be used—one upon each side of the leg. To tone up the anterior group of leg muscles use a foot bath combined with a plate (2x4 inches) over the upper extent of the tibialis anticus

Fig. 29
Method of Applying Cuff Electrodes in Treating Both Ankles by Diathermia.

muscle. In all these methods attach the conductor cords to the edge of the plate or cuff farthest from its fellow.

In treating **both legs** at the same time the feet, slightly separated, may be placed in the *same tray* of saline and the conductor cords attached to a cuff or plate upon each leg (Fig. 29) or the feet may be placed in *separate trays*, each containing a terminal

from the machine, and a cuff or plate electrode fastened upon the leg at the desired point. These cuffs or plates are connected by a piece of wire (6 inches long) with a clip upon either end. The current will then flow from one terminal through the foot, leg and connection to the opposite leg, foot, second terminal and back to the machine, completing the circuit. (See Fig. 43A.)

Knee Joint. The knee joint may be treated by applying two lateral plates, or rubber sponge pads covered with mesh and held in place by an elastic bandage or wooden clamps: or, a cuff may be placed above and below the knee. Again, the knee may be bent and one plate applied above and the other below the patella.

Tesla and Oudin Technic (Indirect Diathermy.)

In Chiropody the Tesla, as well as the Oudin current, is applied by a glass surface electrode attached to one conductor cord leading to designated outlet upon the machine.

These electrodes consist of circular glass bulbs flattened upon one side and may be of vacuum or non-vacuum type. (Fig. 30.)

In the *vacuum* type the air has been partially withdrawn or rarefied, producing a partial vacuum. When electrified they exhibit a violet radiance and for this reason the current which they deliver has erroneously been called the "Violet-Ray". The color displayed varies with the degree of vacuum. Tubes of high vacuum show a light violet color, while those of lower vacuum have a reddish violet color. The latter are more heating and stimulating.

Non-Vacuum electrodes consist of an ordinary glass electrode with an inside coating of silver, or a metallic disk or target enclosed within the bulb. The former type is the best.

Both vacuum and non-vacuum electrodes are known as *condenser* electrodes inasmuch as their action is that of a condenser in which the rarefied air of the vacuum, and the silver lining of the non-vacuum, act as the metallic lining of a Leyden jar, the glass as the dielectric and the patient's body, to which the electrode is applied, as the outer coating of the jar. Thus the electric current introduced upon the inner surface of the condenser electrode *induces* an equal current in the tissues to which it is applied and

oscillates back and forth with each alternating of the high frequency impulse.

Inasmuch as the silver coating, or the metallic target, of a non-vacuum electrode is capable of holding a larger charge of electricity than the rarefied air within a vacuum electrode it is also capable of inducing a large charge within the tissues to which it is applied. Consequently the non-vacuum electrodes are many times more efficient than the common vacuum type and capable of producing a much greater heat within the tissues.

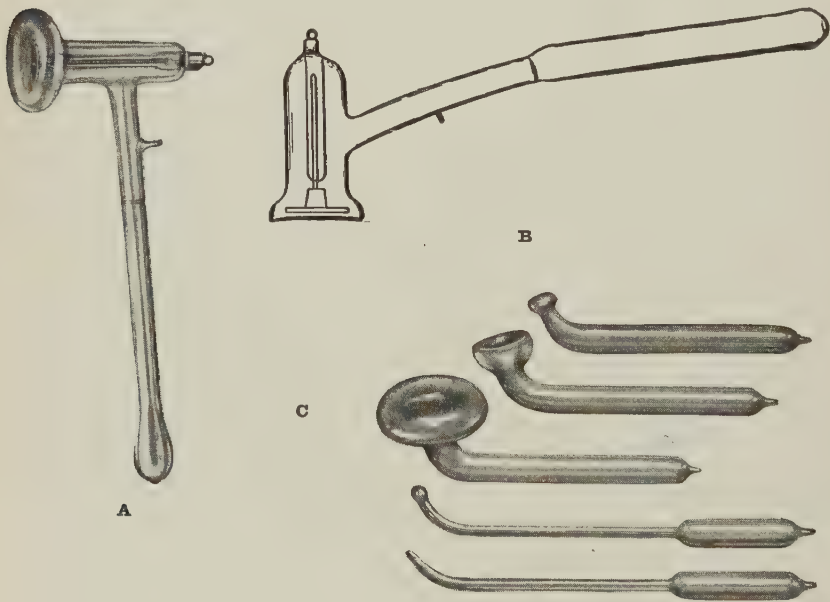

Fig. 30
High Frequency Electrodes. A and B—Non-Vacuum Condenser Electrode. C—Vacuum Condenser Electrodes of Various Types.

Condenser electrodes should be cleansed with alcohol and in the case of the non-vacuum should never be sterilized by boiling or the use of chemicals as such measures will loosen the silver lining and ruin the tube.

Dosage. As the unipolar Tesla or Oudin current does not pass through the milliameter no current reading will be shown. The

best way to test its strength is to bring the tube near a metallic object and note the length of spark capable of being thrown with a given current control. The length and intensity of the spark is controlled by the selective switch, or rheostat, and spark gap as in the D'Arsonval current. Care should be exercised in not using too strong a current in long condenser treatments, especially with the non-vacuum electrodes, as the amount of heat generated is often sufficient to break even large surface electrodes.

Surface condenser electrodes one inch in diameter are a convenient size over the joints of the foot, while those of from 2½ to 3 inches in diameter are adapted to the broader areas of the foot and leg. Small flattened electrodes as used in nose and throat work are useful in treating corns, ulcerations and fissures between the toes. It is needless to say that the heat produced by a small electrode is greater than that of a larger one, the strength of current being the same.

Application of Condenser Electrodes. In order to secure the patient's confidence it is always advisable to use a very small dosage in starting the treatment after which it may be increased by regulation of the spark gap and rheostat. As has been previously explained a mild current is sedative and soothing, a high current heating and stimulative, while a shower of high voltage sparks thrown upon the skin are counter-irritating. The heat generated under a condenser electrode, especially the non-vacuum type, may be increased beyond the point of tolerance. In fact with only a moderate amperage the temperature rise in the tissues is immediate and extends to a depth of approximately two inches and when superficial and not through and through heating is required, this method is superior to diathermia. In rigidity of the metatarsal region and contracted calf muscles the heat produced in this way is admirable.

The condenser electrode should be kept in contact with the skin, unless stimulative sparking is desired, and as the heat increases it should be slowly moved about, care being taken to give a uniform exposure to all parts of the area under treatment.

Talcum powder dusted upon the surface will assist the electrode to slide smoothly and evenly over the skin.

Treatment should be gradually ended by lowering the current slowly and the electrode should not be lifted until the spark gap is closed.

Fig. 30A

Treating an Inflamed Bunion Joint by the Oudin or Tesla High Frequency Current Applied by Means of a Non-Vacuum Condenser Electrode Held in Contact with the Skin.

Modified Condenser Technic. First, the foot may be placed upon an insulated pad, as used in auto-condensation, to which is attached one pole of the *d'Arsonval* apparatus, with the condenser electrode attached to the other pole. Or, a metal plate clipped to one d'Arsonval pole is covered with a sheet of glass or rubber upon which the foot is placed and the condenser electrode attached to the other pole.

Second. A condenser electrode may be attached to each of the

diathermia poles and applied upon opposite sides of the foot or leg.

Third. Another modification consists in applying a metal plate in the same manner as in direct diathermia, but in place of the second plate use a condenser electrode.

Fourth. A large surface condenser connected to the Oudin or Tesla outlet may be held in the hand of the patient while the operator massages and draws the heat to the affected part, the current being grounded through his body.

The heat generated by the above methods does not pass through the tissues as that produced by direct diathermia, nor is it as great.

CHAPTER VI

HEAT

Varieties; Penetration; Super-heated Air; Therapeutics; Apparatus; Technic.

Heat is our most important therapeutic agent from a physical standpoint. It is produced in many ways and is applied in one of three forms;

Conductive heat is that transmitted to a body by direct contact with a heated substance or material, as a hot water bottle, electric heating pad, hot compresses and poultices, sand and mud baths, etc. The heat is conducted through tissues in apposition.

Convective heat is that arising from a source not in contact with the body, as radiant light and heat from the sun or electric light, super-heated air or steam.

Conversive heat is energy converted into heat within the tissues. This is the form of heat produced by the resistance offered to the passage of the d'Arsonval high frequency current by the tissues.

Penetration of heat. It has been demonstrated that heat at 115°F applied directly over muscle tissue will penetrate about ¾ of an inch in all directions, as evidenced by a rise in tissue temperature; while 125°F of conductive heat applied to the abdominal wall of a rabbit showed an increased temperature to the depth of 3 inches and a lateral diffusion of 1 inch.

The heat generated in tissues as a result of the exposure to light is as deep as the penetration of the light rays, or about 1⅜ inches. Conversive heat, or diathermia, may penetrate to any depth, depending upon the strength of the current and proper arrangement of electrodes.

SUPER-HEATED AIR

Hot air "baking" has a distinct place in the treatment of foot and leg conditions but its field is not as broad as that covered by heat produced by radiant energy or tissue resistance.

Physiological action. The physiologic effect of hot air is produced in two ways; first, by thermic irritation of the numerous nerve-endings in the skin. Second, by the actual raising of the temperature of those portions of the body in immediate contact with the heated air.

Irritation of the nerve-endings of the skin results, by reflex action, in, first, marked dilation of the capillary vessels with thinning of their walls and enlargement of the intercellular spaces which results in a greatly increased blood supply and consequent extravasation of blood serum into the tissues. There is also a direct effect upon sensory nerve-endings which brings about circulatory changes in the deeper parts or organs. Second, enormously increased function of the sweat glands, hence increased local elimination. Third, acceleration of cell nutrition and function through reflex stimulation of the spinal centers.

The action of local heat is particularly marked in relieving pain and muscular spasm, and it is these two general requirements, as well as its softening effect upon fibrous adhesions and ankylosis that indicates the use of super-heated air in foot and leg conditions.

The character of the tissues heated influences the penetration and retention of the heat. In vascular areas the rapid diffusion of the heat prevents high temperature in the part, while more dense structures with a limited blood supply will conduct and retain the heat to a greater degree.

Therapeutics. In early inflammatory conditions dry heat, by dilating the superficial vessels and thus increasing the circulation, may make possible the escape of the inflowing blood and arrest or prevent the establishment of stasis. Where stasis already exists hot air baking is contraindicated.

In infected or sluggish wounds which fail to respond to radiant light and heat, or the ultra-violet ray, super-heated air is indicated. This should be applied daily for at least an hour at a temperature of from 300° to 500°F. Whether it is the heat or the active phagocytosis, made possible by the intense hypermia, or both, that

destroy the germ it is hard to determine, but probably the latter. The high heat at least inhibits the bacteria so that they are more easily destroyed by the leucocytes.

Apparatus and Technic.

Hot-air bakers are made in various types and shapes and there are several very satisfactory models for foot and leg application. (Fig. 31.) Heat is produced by means of an alcohol or gas flame,

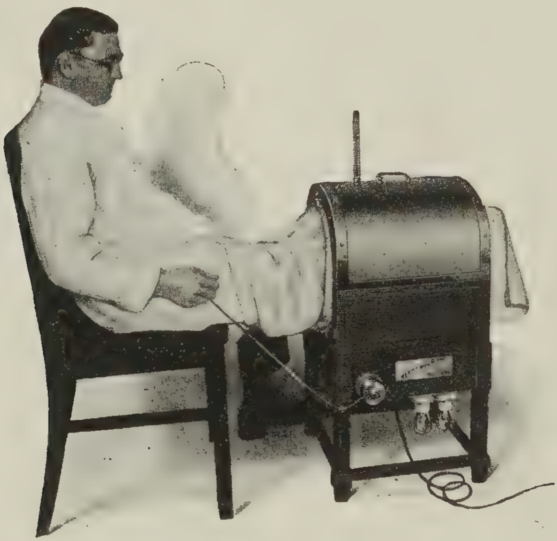

Fig. 31
Applying Super-Heated Air to the Leg.

or better still, in modern apparatus, by electrically heated resistance coils. To be effective an apparatus must be capable of producing 400°F in at least 15 minutes and of maintaining this temperature steadily. It should include an accurate thermometer and ventilator, which should never be entirely closed, with the idea of increasing the heat, because the moisture caused by the heated perspiration may lead to a burn.

Preparation consists in covering the area to be treated with three or four thicknesses of absolutely *dry, loose meshed* Turkish toweling, so as to secure intimate contact between the toweling and the skin. Do not bandage tightly and see that the toes are

well covered. If scar tissue exists upon the part protect it with an extra layer or two of gauze. Advance the heat gradually over a period of five minutes. If the perspiration which is induced as soon as the heat strikes the skin is allowed to remain upon the skin during treatment it will soon boil under the influence of the intense heat and blister the patient. The toweling absorbs the moisture which is vaporized and rapidly diffused out of the wrapping.

A temperature of 250° to 500°F may be used, but in the treatment of a single limb an average temperature of 350°F for 15 or 20 minutes is usually sufficient.

CHAPTER VII

PHYSICS OF LIGHT

Radiant energy; Analysis of white light; Solar spectrum; Sunlight.

Radiant energy. The best known sources of light are the sun, solid bodies at high temperature, such as the filament of the incandescent lamp, and luminous flames. According to the mechanical theory of heat, high temperature corresponds to a violent vibration of the molecules of matter. We may imagine that these particles impart their motion to the surrounding ether in much the same way that a tuning fork generates sound vibrations in the air. Light vibrations or *light waves* are of different lengths, but all very short, the different lengths corresponding to different colors.

There are two units of measurement of light wave length. One is the **Angström unit** (abbreviation A°), which is one ten-millionth of a millimeter in length (1/10,000,000). The other used is the

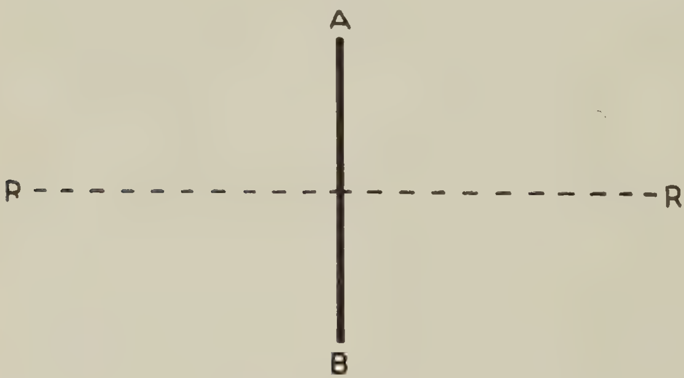

Fig. 32
Light Wave A B. Light Ray R R.

Millimicron (abbreviation the double Greek letter μ. μ.) which is one millionth (1,000,000) of a millimeter in length; consequently a millimicron equals 10 Angström units.

It is difficult for the mind to comprehend such minute measure-

ments. A meter contains a fraction over 39 inches, while a millimeter, which is 1/1000 of a meter, is about the thickness of heavy cardboard.

Light always travels in straight lines. (Fig. 32). Any line RR which cuts the surface of a *wave* of light AB perpendicularly is called a *ray* of light. It is used to express the direction or path in which the wave is moving and along which successive effects of light occur.

Luminous bodies are those which generate and emit light as the sun or electric light. Every point of a luminous body is an independent source of light and emits light in every direction. Exposed to the sun, the skin is warmed, and thus the sense of touch is affected; it is illuminated, and thereby the sense of sight is affected; it is tanned, and thereby its chemical condition is changed. It is evident that we receive something which must come to us from the sun. To the sense of touch it appears to be heat, to the eye it is light, to certain substances it is a power to produce chemical changes. What we receive from the sun is some form of energy and whether it is heat or not we receive something which can be converted into heat.

Analysis of white light.

If a double convex lens of, say, 10 inch focus is placed in front of a small slit cut in a window shade which excludes all light from a darkened room a narrow band of white sunlight will pass through the lens and produce an image of the slit upon a white screen placed in its path.

If the convex lens is replaced by a triangular glass prism so that the beam of sunshine is allowed to fall at right angles upon the surface of the prism it will be found that the light has been turned from its path after emerging from the prism and spreads out fan-like into a wedge shaped body with its base resting upon the screen. (Fig. 33.) The image before only a vertical band is now drawn out into a horizontal ribbon of light and instead of being white now contains all the colors of the rainbow, from red at one end to violet at the other, passing through all the gradations

of red, orange, yellow, green, blue, indigo and violet. This colored stripe is known as the **Solar Spectrum** and the seven colors as the *prismatic or primary colors.* In passing through the prism the red rays are least turned aside from a straight path, are the longest and have the slowest rate of vibration, while the violet rays being at the

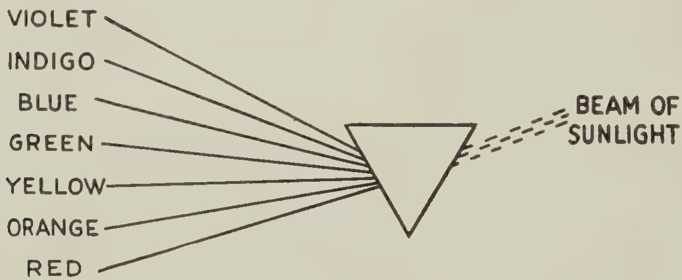

Fig. 33
Solar Spectrum Produced by the Refraction of a Beam of Sunlight through a Glass Prism.

top and refracted at the most acute angle are the shortest and have the highest rate of vibration.

Of the seven prismatic colors red produces the greatest amount of heat, orange the next greatest and yellow still less. These are known as the *thermic* or heat producing rays. Green may be considered a neutral color, having neither thermic or chemical properties. As we go up the spectrum we find that the wave lengths shorten, increasing their vibratory rate as well as their chemical properties; blue slightly, indigo more decidedly and violet most of all. This is known as the chemical end of the spectrum.

If a ray of white or visible light is passed through a prism made of quartz it will be found that the play of prismatic colors has changed. The red, orange and most of the yellow rays, which are heat producing, also some of the green and blue rays, have been filtered out; and yet a photographic plate placed in the path of the rays will develop chemical changes. Evidently non-luminous radiations exist, and such is the case.

At *both* ends of the spectrum there are wave vibrations invisible to the eye and yet having decided physical effects. (Fig.

34.) Below the visible red waves we have the invisible infra-red or heating waves from 7700 to 5,000,000 Angström units in length. Below these are the Hertzian waves of extreme length, up to several hundred feet, with very slow vibrations. At the other end of the solar spectrum, above the visible violet waves, we have the

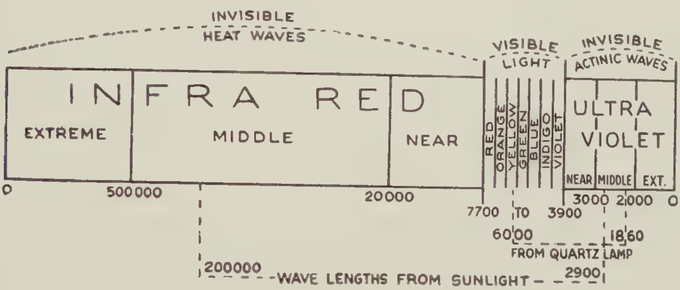

Fig. 34
Diagrammatic Spectrum Analysis. Length of Light Waves Shown in Angström Units.

ultra-violet (Fig. 34) which are divided into the near, middle and extreme. The near ultra-violet waves range in length from 3900 to 3000 Angström units, or about the same as found in unfiltered sunlight; the middle ultra-violet extend from 3000 to 2000 Angström units or about those from mercury quartz lamps. Beyond that we have the extreme ultra-violet waves, a field in which the vibrations as yet are unknown, the alpha, beta and gamma emanations from radium and the x rays. Throughout this entire scale a steady decrease in wave lengths exist from the extreme infra-red rays to the extreme ultra-violet, with a corresponding increase of rapidity of wave vibration.

Sunlight is composed of all the visible and many of the invisible rays, giving us wave lengths from 2900 Angströms through the visible spectrum and into the infra-red. Sunlight contains a small percentage of red rays, 80% yellow and green, 5% blue, and a small percentage of ultra-violet rays, depending upon the purity of the atmosphere, altitude and the time of day. The existence

of moisture and dust in the air cut off the ultra-violet rays, which are greatest in clear mountain air at noonday.

Natural sunlight gives a greater penetration than any artificial ray except radium and x ray, its penetration being about 1⅜ inches in living tissue. Red rays produce the greatest heat and penetrate deeply in living tissue, yellow and blue rays are less heating and penetrating, while ultra-violet ordinarily does not penetrate farther than the superficial layers of the skin. The chemical or actinic properties of the upper end of the spectrum is appreciable in the blue rays, more so in the indigo and most pronounced in the violet, while the ultra-violet are purely chemical rays without heat.

The so-called heat rays are not heat rays in the ordinary sense, but a form of energy which is capable of being converted into heat, and which becomes heat when brought into contact with an opaque body, that is, a substance which is not transparent to light rays. In passing through the atmosphere surrounding the earth a part of the energy of the sun rays is used to heat the air, but the greater part of the radiant energy is developed only when the sun rays meet the resistence of the earth.

CHAPTER VIII

RADIANT LIGHT AND HEAT

Defiinition; Physiological action; Therapeutics; Apparatus; Technic.

Definition; Physiological action; Therapeutics; Apparatus; properly **Visible Light,** consists of the luminous rays produced by electricity in the arc, carbon, tungsten or nitrogen filament lamps. Visible light contains all the wave lengths of the spectrum as well as some of the infra-red rays. When produced by the arc lamp there is also a small percentage of the ultra-violet waves, but practically none with the incandescent lamps due to the fact that these waves cannot penetrate glass.

Physiological Action.

General. Radiant energy is changed into heat in the tissues and is liberated as deeply as the rays penetrate, thus raising body temperature by the diffusion of heat through the quickened blood stream. Metabolism is increased not only as a result of the actual heat produced but probably by mild stimulation of the sympathetic nervous system, resulting in a general tonic action. Radiant light hastens the oxygenation of the blood and acidosis is decreased as the alkaline proportions of the blood increase. Prolonged exposure increases general perspiration.

Local. The initial response to visible light is a marked and immediate hyperemia of the skin and intercellular tissues as a result of capillary dilitation. The skin and its glands are intensely stimulated and if the degree of heat is great and long continued certain reflex vasomotor changes appear to take place which influence distant tissues. As the part becomes progressively heated more blood is brought to carry away the excess heat resulting in increased local activity of elimination and tissue building, as well as increased oxidation. Vascular tissue is penetrated more readily by visible light than any other means, with the exception of diathermia, consequently this energetic response. The analgesic

effect of light is marked, depending upon the amount of heat applied; pain being relieved by relaxation of the tissues and lessened pressure. Muscular contraction and rigidity is overcome, while muscle tire is relieved by increased nourishment of the tissue. Prolonged exposure to radiant light and heat will inhibit, and in some cases destroy, pyogenic bacteria although its effect in this respect is less marked than that of the ultra-violet ray irradiation. However, visible rays are bactericidal in the sense that the hyperemia produced results in an increased number of phagocytes in the tissues, making bacterial destruction possible. Prolonged exposure to visible light results in slight pigmentation of the skin, probably due to the blue and violet rays. This effect however does not compare with that produced by the actinic rays. It has been demonstrated that the visible rays penetrate the skin of negroes more readily than that of whites, and the skin of brunettes easier than that of blonds. Thus tanning increases the absorbing power of the skin for visible light waves.

Therapeutics.

Visible light is one of the most important modalities in chiropodial and orthopedic practice. While the heat produced within the tissues does not penetrate as deeply as diathermia, nor can it be so accurately localized, yet it can be quickly applied and its action controlled by careful technic. Visible light penetrates living tissue to a known depth of 1⅜ inches, possibly a little more, which is quite sufficient in treating most conditions affecting the lower extremity. As a matter of fact it is better adapted for heat production in the skin and superfical tissues than diathermia.

In all cases of an inflammatory nature, acute or chronic, the hyperemia produced by visible rays tends to hasten reparation by increasing the process of waste and repair. Acute localized neuritis, arthritis, bursitis, synovitis and acute sprains indicate the use of this modality. The pain accompanying these conditions is responsive to a high degree of radiant light and heat which acts promptly and effectually. Painful conditions wherever found in

the foot may be treated in this manner. The relaxing effect exercised by radiant light and heat upon spastic or rigid muscle tissue is most gratifying when used in the treatment of contracted muscles of the leg, as found in spastic weak-foot and flat-foot. The same action is also taken advantage of in relaxing tissues preliminary to massage, manipulation or mechanical vibration.

While stiff or ankylosed joints call for direct diathermia, yet in

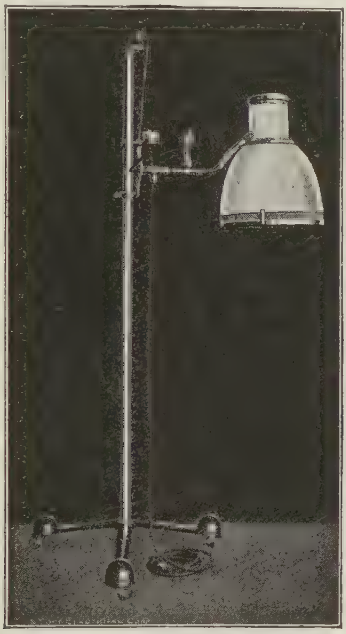

Fig. 35
Therapeutic Lamp for the Administration of Visible Light.

its absence, or in the smaller joints of the metatarsus, visible light is sufficiently relaxing to be indicated. It is especially efficacious in overcoming the pain and rigidity found in depression of the metatarsal arch.

Chronic skin lesions, ulcers, sluggish and infected wounds (if drained) are benefited by the action of visible light which is frequently used to precede the application of ultra-violet rays.

Apparatus.

In the construction of so-called "deep therapy lamps" it is essential that the light is delivered in parallel rays, as any tendency of the rays to focus will result in discomfort and unequal heat distribution which will limit the exposure of the entire area to the skin toleration at the hot spot. The direction and focus of the light waves depend upon the position of the lamp in relation to the reflecting surface, which should be white or highly polished in order that it may absorb the minimum amount of light. (Fig. 35.)

Ordinarily 1000 to 1500 watt lamps are used with reflectors capable of being raised and lowered as well as tilted at various angles. The 1000 watt nitrogen lamp is sufficiently powerful and gives the best all around results. These lamps become very hot after a few minutes use, and it is necessary that the appliance be so constructed that adequate ventilation is secured about the lamp, and especially its neck, to prevent breaking. It is not advisable to tilt the lamp more than 45 degrees from the vertical, as this interferes with uniform circulation of the air about the bulb and may result in overheating. Used upon the 110 volt current a 1500 watt lamp will pull 13 amperes of current, consequently the wiring must be sufficiently heavy to carry the load, especially if other outfits or heating appliances are used on the same circuit. Twenty ampere fuses should be used.

In certain appliances an arrangement exists whereby the position of the bulb may be changed in reference to the reflector making it possible to regulate the light rays as desired. Thus the rays may be more or less focused to produce localized heating or made to diverge and cover a larger area with a minimum of heat production. By the latter method a longer exposure may be used and thus secure the benefit of the few actinic rays found in white light.

While the large single lamp and reflector is a most necessary appliance in the practice of physio-therapy yet it is more adapted to protracted treatment of large areas in general medicine than in the more localized areas treated by the chiropodist. For chirop-

odial and orthopedic work upon the foot and leg the semi-circular reflector containing from eight to twelve cylindrical carbon lamps of 60 watts each is especially adapted and a most satisfactory instrument. (Fig. 36.) These reflectors or "electric light bakers" are so hinged at the top that the two reflecting wings may be separated at various angles and thus adapted to various positions and surfaces, while a selective switch permits the operation of all or part of the lamps. The total amount of light rays generated are less than that of one large lamp but to off-set this the small reflector may be quickly brought near the body, an intense heat

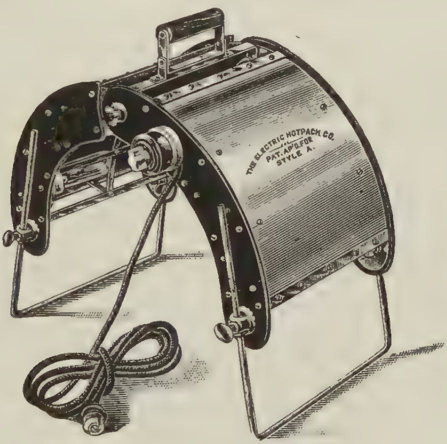

Fig. 36
Visible Light Reflector Adapted to Foot and Leg Treatment.

generated and as quickly removed to another area when the point of skin toleration has been reached. This is a most important feature in foot work.

Reflectors of this type are usually equipped with adjustable legs so that they may be placed over a part and allowed to remain without farther support in this position. Unless a low degree of heat is desired for a considerable length of time this arrangement is of little value. To secure the best results by the use of the collapsible reflector it should be suspended over the foot-rest of the operating chair and so arranged than it may be raised and lowered

as well as tilted in any position. This may be accomplished by removing the crossbar to which the handle is fastened and slipping a metal ring, 1½ inch in diameter, over each end of it, the handle separating the rings. A light, closely woven rope, known as awning cord, with bifurcated ends terminating in small harness snaps is attached to the rings of the reflector while the other end is passed through a small pulley fastened to the ceiling immediately over the foot rest of the operating chair. From this point the cord is carried to another pulley upon the ceiling at its junction with the side wall, over this and part way to the floor, terminating in a counter-weight consisting of a sand bag or sash weight of sufficient weight to balance the reflector. By this arrangement the appliance may not only be raised or lowered with the slightest effort but the freedom of movement secured by the sliding rings permits it to be tilted or inclined in any position about the foot or leg, and held there with but little exertion.

Technic.

The toleration of the patient should be the guide in using visible light, there being no standard distance at which the application is made. Orthopedic and chronic cases demand the maximum amount of heat for a period of from ten to forty minutes, depending upon the condition. In acute inflammatory or painful conditions where an energetic hyperemia is desired a short, intense application of from three to ten minutes is indicated. To secure the best results visible light should be used to the point of toleration and held there as long as possible, removing it to another location when the heat becomes too intense and then returning to the old area. This means that the operator, or assistant must control the appliance constantly and not leave it for a moment. Ten minutes of an intense application, with all lamps in service and the reflector held as close to the part and as long as can be tolerated, will secure better results in orthopedic cases than thirty minutes, or even sixty, of low heat. It is better to make a personal, scientific application than to place the reflector over the part, switch on part of the bulbs and carelessly go about other business. The secret

in using visible light in foot and leg treatment, with a few exceptions, is the application of intense heat for short intervals. Where long exposures are required the part should be intensely heated and then slowly exposed to a lower degree of heat. It should not be forgotten that the tissues grow progressively hotter as the treatment persists, consequently an exposure which may be tolerated by the patient at first will become intolerable later on. Massaging the heated area gently during the exposure will increase heat toleration.

Radiant light and heat should be used with caution upon thin, sensitive skins, over scar tissue or parts in which sensation is impaired or lost. Again, it must be used with extreme caution in cases of varicose veins where the superficial vessels are greatly distended.

A modified method of visible light application consists in wringing two or three layers of coarse mesh gauze out of warm water, applying this over the part and directing full heat upon it until the moisture is evaporated. This produces a steaming hot pack, with a limited exposure of light rays, which is efficacious in treating swollen and painful areas, as acute sprains, synovitis, acute bunion, etc.

The absorption of alterative ointments and inunctions is hastened by the use of visible light before and after the application of the medicament.

CHAPTER IX

ULTRA-VIOLET RAYS

Definition; Properties; Physiologic action; Apparatus; Therapeutics; Technic.

Definition.

Ultra-violet, Quartz or Actinic rays are called ultra-violet because they lie beyond the visible spectrum, actinic because they exert a chemical action, and quartz because they pass readily through quartz crystal. They are classified as near, middle and extreme. (Fig. 34.)

Properties.

Sunlight contains the longer ultra-violet waves, ranging in length from 3,900 to 2,900 Angström units. The existence of moisture, dust or organic matter in the air acts to cut off the ultra-violet waves, which are most numerous in the air found at high altitudes at noonday.

The light from the mercury vapor lamp contains these longer waves as well as the shorter chemical wave lengths down to about 1,860 Angström units which are found in the middle ultra-violet region. The rays of still shorter vibration lengths in the extreme ultra-violet region are not used therapeutically.

Ultra-violet rays will not pass to any extent through glass, paper, cloth or oily substances and this is the reason that light from incandescent lamps contains but a very minute quantity of these emanations. Sterile water, quartz and fluorspar are transparent to the actinic rays.

The shorter the vibration rate the less penetration in living tissue. Actinic rays from the air-cooled mercury vapor lamp penetrate but little below the skin, due to the fact that the hemoglobin of the blood is opaque to their passage. When the superficial capillary circulation is cut off by pressing a surface quartz applicator against the skin the penetration may be increased to an

inch or more, depending upon the completeness with which the blood is expelled from the part.

Ultra-violet rays are known as "cold rays" and the skin is insensible to their passage, while any heat experienced is that reflected from the highly heated lamp itself. Likewise the rays are invisible to the naked eye, the light being perceived consisting of the blue, green, violet, indigo and possibly some of the yellow rays from the visible spectrum.

Physiological action.

General. The longer wave lengths developed by the air-cooled lamp may be considered as tonic, resulting in increased metabolic changes and elimination. The red blood cells are increased in number as well as the percentage of hemoglobin, while the white blood cells are decreased temporarily, to be followed later by an increase in number, which is permanent. The calcium, iron and phosphorus contents of the blood is increased as evidenced by calcification of bone as found in the treatment of rickets.

Local. Skin reaction to the chemic waves is the outstanding manifestation. This is governed by the distance of the burner from the surface, length of exposure, voltage of current, susceptibility of the skin to these rays, the make and type of lamp.

The skin reaction may be so slight as to cause the faintest blush or erythema or carried to the point of actual blistering and destruction of the superficial layers of the skin. Superficial capillary engorgement with stimulation of surface epithelium is the result of mild dosage, a larger dosage produces marked capillary engorgement with destruction of surface cells and stimulation of the deeper cells, while a "destructive dosage", so called, destroys the superficial layers of the skin with blistering and vessication.

The erythema produced by actinic ray exposure does not appear for several hours in contra-distinction to that of an ordinary heat burn which appears at once and an x-ray burn which may not be evident for several days.

Blistering and destruction of the superficial layers of the skin is the most severe local effect possible to secure by actinic ray

exposure. It is not a burn, but a dermatitis, and will heal without a scar; in fact one of the best treatments for any burn is properly administered actinotherapy. The rays from a mercury vapor lamp are constructive, quite unlike the destructive x-ray and radium emanations. It must be understood that the burner of an air-cooled lamp becomes exceedingly hot and if brought too near the skin will produce a *heat burn,* but this is not an actinic ray burn.

Fig. 37
The Alpine Sun Lamp. An Air-Cooled Lamp for Alternating Current.

The effect of these rays upon the blood vessels consists in the production of an active hyperemia of their endothelial lining, with a proliferation of the endothelial cells.

Actinic ray exposure relieves pain, probably as the result of the counter-irritation produced and possibly by special action upon the sensory nerve endings.

Short ultra-violet waves are bactericidal and it is in this field that their use is especially indicated. Wave lengths of between 3000 and 2000 Angström units, found in the middle ultra-violet region, are those especially energetic in the destruction of bacteria. Micro-organisms within the tissues have been killed to a depth of 1½ millimeter. The time required to kill various bacteria in sterile water at a distance of 200 millimeters is as follows: Diplococci, 6 seconds; Staphlococci, 10 to 12 seconds; Streptococci, 14 to 25 seconds; Bac. Diptheriae, 10 seconds; Bac. Tubercle, 12 seconds; Bac. Typhoid, 18 seconds.

Apparatus.

Two types of ultra-violet lamps are used, the first is known as the *air-cooled* and the second, *water-cooled*. There is a difference in the quality of the light emanating from the two types as well as their therapeutic use. The wave lengths developed by mercury vapor lamps are very short, running from 6000 down to 1860 Angström units. In the air cooled lamp the long ultra-violet waves predominate, while the water cooled lamp gives a larger proportion of the short, or far, wave lengths. The former is used for general radiation while the latter is used for intense local treatment. (Fig. 37.)

Quartz burners, or targets, are used in the construction of ultra-violet lamps for three reasons, first, that quartz allows more actinic rays to pass than any substance except fluorspar, and second, that it has twice the melting point of ordinary glass which would melt under the very high temperature reached in these lamps, third, that quartz filters out the red, orange, yellow and some of the green and blue rays of the visible spectrum.

Two types of quartz burners are used. One consists of two electrodes of liquid mercury within a vacuum chamber, the arc discharge taking place between the electrodes. The other burner has a cathode of liquid mercury while the anode is a flat coil of tungsten wire which is at a low red incandescence when the burner is operating. In the water-cooled lamps a space, or jacket, surrounds the burner which is kept cool by a constant circulation

of water, thus permitting it to be used in contact with the tissues without producing a heat burn. The window which allows the light from the burner to pass through the water must be of quartz and may be placed in contact with the skin, or solid quartz applicators may be used to produce compression and thus secure intense results in the tissues partially deprived of their blood supply.

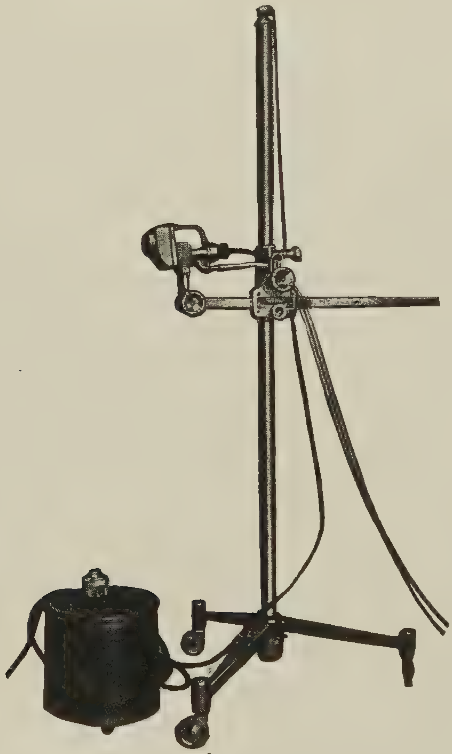

Fig. 38

The Kromayer Lamp. Water-Cooled Direct Current Type.

The mercury quartz vapor lamp gives better results when operated upon a direct current; where the alternating current is furnished it will be necessary to use a rectifier or transformer. A voltage of 85 or 95 is generally used and upon its uniformity depends the character of the ultra-violet output; a slight drop in voltage causing a wide variation in the quality of the ray. (Fig. 38.)

Quartz burners deteriorate with use. Due to the intense heat of the arc enclosed by the quartz a devitrification takes place which cuts off the passage of the shorter actinic rays more and more as the lamp is used. The longer rays are changed but little. This condition is not as pronounced in the burner of the water-cooled lamp as in the air-cooled on account of the better cooling of the former.

Dosage.

Dosage is roughly calculated by the degree of erythema or skin reaction produced, as follows:

1. *Stimulative* erythema consists of a reddening of the skin. This is the exposure used in general treatment.

2. *Regenerative* erythema is a marked redness with a decided hyperemia and destruction of the surface cells, a point just short of blister formation. This is the dosage used in inflammatory skin lesions.

3. *Destructive* erythema consisting in vessication and blistering of the superficial layers of the skin. Used in infective and degenerative skin lesions where decided localization is desired.

In the application of actinic rays no arbitrary rule for dosage is practical as several factors influence the output of the lamp and the results obtained, namely: the make and type of generator; current voltage; age and clearness of the burner; target-skin distance; duration of exposure and condition and sensitivity of the skin.

Voltage variation plays an important part as previously stated, also the age and transparency of the burner. Upon the distance between the burner and the skin depends the length and consequently the therapeutic action of the ray. The term "target-skin" distance has reference to the distance between the target, or burner, (not the hood) and the skin. The duration, or timing, of the exposure depends upon the desired reaction, plus the wave length.

Skin reaction depends upon its character, texture and condition. Generally speaking old people require longer exposure than young

adults, and children still less. Females are more sensitive than males. The skin of blondes is more sensitive than that of brunettes. A tanned skin requires much more exposure than one untanned. A hard, indurated skin is opaque to actinic rays and must be softened before treating, while the accumulation of secretions, scabs and crusts, as well as the presence of oil or dirt, act in the same manner and must be removed. The skin upon the back of the legs and the soles of the feet is less sensitive than that upon the anterior surface of the leg and the dorsum of the foot.

Various methods have been tried in an effort to standarize actinic ray dosage with reference to the output of the lamp and the patient's susceptibility, but so far these efforts have failed to obtain accurate results. The only practical method consists in cutting several holes, one inch in diameter, in a piece of black paper, cloth or adhesive plaster and placing it upon the area to be tested. Cover all the openings but one. With *air-cooled*, 110 volt lamp at 8 inches target-skin distance expose the skin showing through the opening for one-half minute. Cover this opening, uncover another and give this a one minute exposure. Again cover the aperture and give another area an exposure of one and one-half minutes. This proceedure may be continued on successive days until the point is found at which blistering takes place. In this way the time required to produce various degrees of erythema may be ascertained and the skin reactions, which appear in from 3 to 6 hours, may be compared.

With the dosage known at an 8 inch target-skin distance the reaction produced at a longer or shorter target-skin distance may be arrived at by applying the law that "intensity of light varies inversely as the square of the distance." In other words, decreasing the target-skin distance one-half increases the dose four times; or again, doubling the distance quarters the dose.

When a test is not made the resistance of the individual skin may be determined by an exposure of one-half to one minute, using the air-cooled lamp at 24 inches target-skin distance, gradually

increasing the exposure period from one-half to one minute daily until periods of ten minutes are reached.

To standardize the dosage of a *water-cooled* 110 volt burner the same method may be used by applying the front window of the lamp in contact with the skin (not under pressure) and expose the first area 5 seconds, the next 10 seconds, the next 15 seconds, the next 20 seconds, etc. Ordinarily the skin will blister by the use of this method in one minute or less. Where a solid quartz applicator is used in contact it will take a little longer than one minute to blister the skin, but if used in contact under *compression* the interval will be very much shortened.

Technic.

The lamp is put in operation by switching on the current at the transformer after which the burner is tilted to allow the column of mercury to flow between the two electrodes and form a contact. Immediately the burner is tilted back to its former position, breaking the mercury and starting the arc. Until the mercury is heated the resistance is great and a high voltage, which is only partially registered by the voltmeter, is required. Later the vapor becomes intensely hot and the voltage reading increases. Consequently the lamp should be allowed to heat up for 5 or 10 minutes in order to develop its full output before using. During treatment it should not be tilted more than 20 degrees from the vertical position. With water cooled-lamps a free circulation of water should be provided. This should be cut off before the current is switched off to allow the water, burner and jacket to become warm (not hot) and thus prevent cracking due to sudden cooling. The same result is secured in the air-cooled lamp by closing the hood and covering the lamp with a towel for a few seconds before switching off the current.

A quartz burner gradually deteriorates with age, the water-cooled less than the air-cooled, due to the intense heat causing a gradual formation of a substance known as tridymite which filters out the short ultra-violet waves. The longer waves are not ef-

fected. Usually a burner can be used a thousand hours or more before this change prevents its use in short wave exposures.

The burner should be kept clean by wiping it off with alcohol as even finger prints upon the quartz will refract the rays from their direct path.

Variation in voltage alters the quantity and quality of the ray being generated in the lamp. Voltage varies in different places and at different times of the day. A drop of 4 or 5 percent in voltage means a drop in ray efficiency of several times that percentage. When the voltage is low, due to a heavy load upon the circuit, increase the time of exposure, or if possible regulate the voltage at the transformer.

The **Air-cooled** lamp may be used for short wave or local treatment, or for long wave or general treatment. The aim in *long wave* treatment is to secure a tonic effect as the result of the saturation of the blood with the actinic rays. The object in producing a mild erythema is not for its local effects, but rather to act as a guide in regulating the dosage. A second degree erythema should not, as a rule, be produced in general treatment. Exposure should be made at a target-skin distance of about 40 inches, which may gradually be decreased as low as 14 inches, but in general treatment it is better to hold it to the former distance and increase the length of exposure gradually every two or three treatments until the patient is receiving a time exposure of from 15 to 20 minutes. Where the entire body is to be treated it should be divided into four or six zones, giving a one minute exposure over two or three zones one day and exposing the remaining areas upon the day following, gradually increasing the length of exposure until the skin tans.

The *short wave* **technic,** with air-cooled lamp, is used where a larger surface is to be treated than can be covered with the water-cooled lamp. The safest target-skin distance in local, short wave application is 8 inches, with an average surface exposure of about 4 minutes. However sufficient dosage should be given to produce

the desired reaction and this can only be ascertained by making a skin test.

The **Water-cooled** lamp is used only upon small areas for local treatment where it is desired to produce intensive reaction by the short actinic wave lengths or secure their pronounced bactericidal action. A regenerative reaction may be secured by placing the quartz window at a distance of one or two inches from the skin and giving an exposure of from 30 seconds to 2 minutes. With the front of the window in contact with the skin (not under pressure) a blister will be formed in one minute or there-abouts.

The *Compression* method consists in cutting off the blood from a localized area by pressing the solid quartz applicator firmly against the part. As the blood stream absorbs most of the actinic rays coming in contact with it the localized anaemia, produced by compression, permits a deeper penetration and a quicker reaction. The compression method should be used with caution and very short exposure, 10 seconds will frequently produce a decided dermatitis lasting for a week. The area under treatment should be localized by covering it with a cut-out shield of adhesive plaster. Adjacent surfaces should be protected against the rays by covering with a towel.

The eyes of patient should be covered with cotton if treatment is to be applied about the face or head and glasses opaque to the violet-ray should be worn if there is any danger of exposure to direct radiation. An operator constantly doing this work should wear opaque glasses as a conjunctivitis may be produced even if he is out of the line of direct radiation.

The application of radiant light and heat preliminary to ultra-violet ray treatment is quite generally practiced. The hyperemia and heat produced by visible light in superficial tissues increases the action obtained by actinic radiations. This result is especially marked in open wounds and local skin lesions.

Therapeutics.

The field of quartz ray therapy in chiropody is more or less limited, being largely confined to local conditions and small areas.

Its most valuable use is in the treatment of localized skin lesions as ulcers, sinuses, fistulous tracts and sluggish wounds. Among the skin lesions found upon the foot the various forms of eczema are especially amenable to actinic radiations, also ringworm and psoriasis. These should be treated in small areas with the air-cooled lamp at 8 to 12 inch target-skin distance. Fistulous openings and sinuses are treated in the same manner. Acute inflammatory conditions as bursitis, abscesses and infected wounds demand short wave application with the front window in contact, or by the use of the surface applicator and compression. Neuralgia and other painful conditions are frequently benefited by the long wave technic, while acute localized neuritis, as of the plantar nerves, is treated with a regenerative dose from the air-cooled lamp at 8 inches. Chilblains of long standing may be treated with a regenerative dosage from air-cooled lamp at an 8 inch target-skin distance. Paronychnia is benefited by a long wave tonic treatment. General long wave treatment would only be used as a tonic measure in connection with local foot treatment.

CHAPTER X

INFRA-RED RAYS

Definition; Properties; Physiological action; Therapeutics; Technic.

Definition.

Infra-red Rays are invisible, heat producing, light waves, lying below the solar spectrum and as used clinically run in length from 7,700 to 150,000 Angström units. The infra-red radiations are divided into the near infra-red from 7,700 to 20,000 Angström units, the middle infra-red from 20,000 to 50,000 Angström units and the extreme infra-red from 50,000 to 00.

Properties.

Solar radiations consist of 80% infra-red frequencies, 13% visible and about 7% ultra-violet. The infra-red rays differ from those of the ultra-violet in that they are much longer, are thermal or heat producing rather than actinic or chemical, and that they pass readily through an atmosphere fogged by dust or smoke. Water, glass and quartz absorb these rays, consequently they are not obtained by the quartz lamp.

Physiological Action.

Heat is produced within the tissues by the absorption of infra-red rays which are evidently capable of deep penetration. The production of a deep hyperemia, with all its signs, symptoms and phenomena, indicates its local action upon the tissues. An actual rise of body temperature is demonstrable.

Production.

Infra-red rays are produced artificially by heating any black body (one capable of absorbing radiant energy) to a high degree by electricity, which refracts the rays to an absorbing body thus generating heat within it. The present infra-red appliances consist of a generator, composed of silicates and certain oxides fused in ring or U shape, which is attached to a reflector. In some

appliances this reflector and generator is so made that it can be used within the hood of a deep therapy lamp.

To be efficient these generators must be capable of maintaining high, uniform heat for long periods. As they are heated to such a high degree the reflector should contain a safety screen to protect the patient against falling heated particles in case of breakage.

Therapeutics.

Infra-red rays are indicated where superficial heat is desired. The arterial hyperemia produced relieves stasis and painful conditions. This modality can be used wherever convective heat is indicated, as in neuralgia, neuritis, arthritis, myositis and inflammation of the synovial structures.

Technic.

These rays may be used with perfect safety to the point of skin toleration for short intervals or by longer exposures of moderate intensity. In the latter instance they may be used by the layman to take the place of hot water bottles, salt bags, etc.

CHAPTER XI

MASSAGE AND MANIPULATION

General Consideration.

Massage and manipulation are important factors in orthopedic treatment of the leg and foot. By this is meant scientific massage applied by one who knows the anatomy and physiology of the tissues under treatment and the pathology of the existing condition. A mere rubbing or "man-handling" of the part is not massage and may result in untoward results.

Generally speaking the mechanical effects of massage are the most important. They consist in a stimulation of the interchange of cell contents, as a result of alternate pressure and relief from pressure, in increased activity in the movement of the fluids in the areolar tissue and noticeably in the acceleration of the currents of blood and lymph in their respective vessels. By this interchange of tissue fluids food is brought to the diseased or injured area and waste matter carried away. In other words massage promotes metabolism, nutrition and tissue repair.

By direct mechanical action massage breaks up adhesions and fibrosis as well as assisting muscles and joints to resume their functional activity, not only through the force exerted by the procedure but by its passive suggestion. Muscles weakened and fatigued as the result of over-use, improper attitudes or mis-use are freed from sarco-lactic acid and other fatigue toxins by massage, becoming stronger, contracting more readily and vigorously Practically the same results are produced when the muscles are manipulated as when they act themselves. In those weakened or paralyzed by disease or traumatism massage is indicated *after* nerve regeneration has taken place and the muscle fibres regain functional activity by the application of the galvanic and sinusoidal currents.

Massage stimulates the activity of the skin glands and other superficial glands which may be reached by manipulation, as well

as relaxes superficial scar and callus tissue. Most inflammatory conditions of a subacute or chronic character, whether toxic or traumatic, indicate the use of massage as an aid in stimulating the normal functions, increasing absorption and thereby decreasing congestion and inflammation.

Massage is *contraindicated* in swellings which might be malignant; over areas in which pus is confined as abscesses; in acute,

Fig. 38A
The Patient Holding the Auto-Condensation Handle, Which Is Attached to the Oudin or Tesla Terminal, While the Operator Massages the Affected Part, Drawing the Heat to That Location, the Current Being Grounded through His Body.

deep inflammatory processes of all kinds; in acute skin lesions; in acute phlebitis and should be used with care over superficial varicose veins as well as in acute, local lymphangitis.

Preparatory to massage the foot and leg should be extended in a comfortable, relaxed position. The clothing, unless very loose, should be removed, at least well above the knee, as it will constrict the veins and lymphatics if it is turned or rolled up and

interfere with the proper emptying of the area under treatment. The temperature of the room should be high enough to preclude the possibility of chilling the exposed part and the operator's hands should be warm. It is unnecessary to use lubricants or massage creams upon the skin unless it is very dry or there is callus formation to be softened. Boric acid or plain talcum powder reduce friction and are much better suited to the purpose than ungents.

In order to carry out the principle of massage it is necessary to take into consideration the presence of valves in the veins and lymphatics which hinder the retrogression of the blood and lymph. Consequently in massaging a limb the manipulations should always begin at the *proximal* end of the limbs and the veins and lymphatics emptied first in that area, gradually coming down until the entire limb has been covered.

Massage of the lower extremity should always be preceded by the use of heat in some form. This is used for a two-fold purpose; first to bring more blood to the tissues making it possible to massage more blood and lymph, with their contained waste products, out of the tissues. Second, to relax and soften spastic muscles and fibrositic areas.

To increase the vascularity of soft tissues the application of visible light should be intensively applied for 10 or 15 minutes, or infra-red rays may be used for the same period. In the absence of these modalities the non-vacuum condenser electrode may be applied over the entire area, using as strong a mono-polar high frequency current as can be tolerated by the skin with the electrode slid slowly over the surface from place to place for 5 or 10 minutes. A hot foot and leg bath continued for 5 minutes is indicated where other means of heating are unavailable. Before deep seated conditions, ankylosis and fibrous adhesions are to be manipulated the diathermia current should be used to secure its softening action for half an hour. The electrodes should be applied in such a position that a through-and-through heating is produced in the area of fibrosis.

In applying massage as part of the treatment in longitudinal

arch deformities it should be directed primarily to the leg muscles and secondarily to the foot structure. While it is true the deformity is of the arch the underlying cause is found in the muscles of the leg which move the foot and govern foot posture.

The longitudinal arch may be compared to a suspension bridge, in which the suspending cables correspond to the leg muscles, the actual bridge structure to the bony arch and the guy wires and cables to the ligaments and muscles of the foot. Stretching or breaking of the suspending cables results in the bridge structure sagging or falling, and by the same token weakness or paralysis of the leg muscles results in strain, depression or obliteration of the longitudinal arch. As long as the leg muscles are in good tone and equilibrium their bow-string tendons will maintain the bones of the arch in their normal position and depression of the arch will be almost impossible.

In weak-foot and flat-foot the muscles which tire and lose their tone are principally those which adduct and dorsi-flex the foot upon the leg, namely, the tibialis anticus, the extensor longus digitorum and the tibialis posticus. Those muscles which over-function and contract are the powerful calf muscles and the peronei. The former require tonic, stimulative massage; the latter massage and manipulation tending to soften and relax. Until the weaker anterior group is able to resist the stronger posterior group the foot is bound to abduct and avert and this attitude of deformity, which is the primary cause of longitudinal arch depression, will persist.

Massage Technic.

There are five movements used in massage, of these the first three are the most important, the latter two being modifications of the others.

1. Effleurage or stroking.
2. Pétrissage, pinching or kneading.
3. Tapotement, hacking, clapping or percussion.
4. Friction.
5. Vibration.

Effleurage or stroking is done by using the palmar surface of one or both hands upon the larger areas of the leg and foot, or the palmar surface of the thumb and fingers may be used over small areas, over tendons and upon the toes. The stroke should be firm, not heavy, and of a clinging character. It should commence upon the upper surface of the leg and thigh and follow the direction of the venous and lymphatic flow and should be uniform and continuous from beginning to end, the hand not being raised from the skin. The return stroke should be very light and return to a point a short distance below the beginning of the previous downward movement. The entire area should be slowly massaged in this manner as the limb is gradually descended. In stroking the toes a spiral movement may be used.

In light, slow stroking the action is sedative and relaxing, the superficial circulation is slightly lessened and sensitive sensory nerve endings are soothed and quieted. Deeper, faster stroking is stimulative, resulting in an accelerated return flow of venuous blood and lymph which indirectly hastens the in-flow of arterial blood and newly formed lymph to the area massaged thus bringing about the best conditions for nutrition.

Pétrissage, pinching or kneading, should follow effleurage where the deeper structures are to be manipulated. This consists in movements in which the structures in the area are alternately picked up, kneaded or rolled between the fingers or hands and then relaxed, the force exerted being in the upward direction and toward the larger veins and lymphatics. The movements from one area to another should be gradual and the tissues in one area should not be completely released until those of the next are under manipulation, in order that there may be no back flow of the fluids. This is the most difficult massage movement to perform and explain. In working upon a single toe use the tip of the thumb and first finger of one hand placed laterally, and the other antero-posteriorly. Alternate pinching is then done from the tip to the base of the toe. In the legs the muscle groups are grasped between the thumbs and fingers, starting from the ankle and work-

ing upward. The calf muscles may be kneaded by grasping the leg behind with one hand and in front with the other, the right hand slightly above the left and the ball of the thumbs about two inches apart. The tissues are kneaded between the thumb as the hands move slowly up the calf. The purpose of these movements is to stimulate both motor and sensory nerve endings, empty the deeper structures of blood containing fatigue and toxic products and to relax adhesions and fibrosis. The kneading movement stimulates muscular contraction as a result of the mechanical stimulation. Undue force should not be applied by this method and the time period should be short.

Tapotement, hacking, slapping or percussion, is the most stimulating of massage movements. It may be delivered by the outer edge of the hand, by the edger of the outer fingers, by the finger tips or by the flat or cupped hand. The edge of the hand is used where deep effects are desired, the operator's muscles being held in a state of contraction and the blows being delivered with a stiff wrist in a slow, hacking or chopping motion across the long axis of the muscles. It is used in local muscle spasm, for the breaking up of fibrosis and for the stimulation of the deeper circulation. It should not be used over bony prominences or joints. In light hacking the fingers are relaxed and slightly separated, and in striking the body the little finger hits first and the others in succession. The blows should be rapid and of a rebounding character. Slapping is performed with the palmar surface of the fingers, by quick, light, alternate strokes, wrist relaxed and the fingers immediately rebounding from the skin surface. Slapping acts chiefly upon the skin, stimulating its sensory nerve endings and bringing about reflexly an increased flow of blood to the part as well as a general stimulation.

Vibration is best accomplished by a mechanical vibrator and will be considered under this heading.

Friction is produced only by applying the tips of the fingers and thumbs to the skin, with varying degrees of pressure, which is moved over the underlying tissues. The movements are circular

in character and are used to break down adhesions, remove scar tissue and swelling about joints and tendons.

Manipulation.

Manipulation is one of the most essential factors in orthopedic treatment. It is especially indicated in the treatment of the various deformities of the human arch with restricted joint motion, either as the result of fibrositic changes or contraction of muscle tissue or misplaced bones.

Motion is *active, passive or resistive.* Active motion is that produced by the patient, passive motion is the result of force applied by the operator, resistive motion is where an effort to move the part by the patient is antagonized partially by the resistance interposed by the operator.

Before practicing manipulative methods the structure of the tissues, function and normal range of motion, as well as pathologic changes, must be taken into consideration. In manipulation directed toward the restoration of foot and ankle movement it is necessary that the normal range of motion is known and where it takes place. Limited motion is one of the earliest signs of loss of function and consequent weak-foot. This range of motion varies somewhat within normal limits; it is equally greater in childhood than in later life, greater in the slender than in the blocky, massive foot, and greater in the foot used properly than one that is not.

Dorsal flexion, or flexion of the foot upon the leg, and *Plantar flexion*, or extension of the foot, take place only in the ankle joint. With the leg fully extended at the knee the patient should be able to dorsi-flex the foot to an angle of about 75°, or about 15° less than a right angle, and plantar-flex to about 135° or 45° more than a right angle. Extreme dorsi-flexion is accompanied by slight adduction.

Adduction and *Abduction* of the foot take place in the medio-tarsal and sub-astragaloid joints. Voluntary adduction is always associated with *inversion* or suppination of the foot. Its normal range of motion is about 30°. Voluntary abduction is always

associated with *eversion* or pronation of the foot. Its normal range of motion is about 15°.

Simple inversion and eversion can be carried out to full extent with the foot at a right angle to the leg, but complete adduction is only attained in the position of plantar flexion, while extreme abduction is attained in the attitude of dorsi-flexion. Observations as to the degree of active adduction and abduction should be made upon the outer border of the foot, the contour of which is comparatively straight and incapable of being distorted by the patient in an effort to produce the desired motion. Lateral ankle motion must also be discounted. In testing dorsal flexion the plantar surface of the foot should be used as a guide, inasmuch as the extensor brevis digitorum will hyper-extend the toes in an effort to assist the extensor longus digitorum in dorsi-flexing the foot. This is especially noticeable in those cases in which the anterior leg muscles are partially weakened or paralyzed.

Passive or involuntary dorsal flexion is about 5° to 10° beyond that of active dorsal flexion, while passive plantar flexion is about the same as that produced actively by the patient. The limits of passive adduction and abduction are considerably beyond those of voluntary adduction and abduction.

The test of passive motion serves several purposes, contrasted with the range of voluntary motion it shows the habitual use of the foot, since the motion least used is the motion most limited. It also makes evident the slight restriction of motion and the presence of tenderness, which, even in early cases, are usually present. Thus, if pressure be made just in front of and below the internal malleolus, at the astragalo-scaphoid junction, and if at the same time the foot be suddenly adducted, the patient will complain of pain at the point of pressure and a feeling of constriction and tension about the dorsum of the foot, before the normal limit of motion is reached. When the foot is dorsi-flexed the plantar fascia is put upon the stretch and its condition may be noted, for a contracted and sensitive plantar fascia may cause

symptoms of disability that induce, or are combined with, abduction and eversion.

The degree of manipulation directed to the restoration of joint movement in longitudinal arch deformity depends upon the extent and nature of the condition. If the range of voluntary adduction and dorsal flexion is but slightly decreased with passive motion normal the only manipulation necessary will be that applied in the form of stimulating massage to the anterior leg muscles. If. however, the rigidity in and about the medio-tarsal joint is great, with marked lessening of normal motion it will be necessary to determine the cause. This may be due to a changed position of the bones entering into the formation of the longitudinal arch with changes in their articular surfaces or to a spastic condition of the muscles extending and abducting the foot.

In the latter case these contracted muscles must be relaxed and softened before manipulative force is exerted in an effort to stretch them. Preliminary heating of the spastic muscles, either by visible light, diathermia, super-heated air or the use of the non-vacuum condenser electrode should be accomplished, after which the contracted leg muscles should be relaxed by deep vibration or massage. Before attempting to stretch these muscles the foot should be placed in extreme adduction and inversion, the heel being held firmly in one hand thus locking the joints and preventing flexion from taking place in the medio-tarsal joint, which is possible in cases where the ankle joint does not permit free flexion. Again, the traction put upon the os calcis during the process of stretching the calf muscles would cause it to tilt further unless supported by the hand. The leg should be held straight with the knee unbent during this manipulation, thus maintaining the extreme length of the gastrocnemius from its origin upon the femur to its insertion upon the os calcis.

The foot being thus supported the patient should be directed to dorsi-flex and invert it as much as possible and offer no resistance to the force exerted by the operator, in an attempt to

secure additional adduction and dorsi-flexion. It is useless to apply sudden and extreme force as it will only result in powerful antagonism by the muscles and tiring of the operator. The force should be gradual and uniformly applied, becoming stronger as the muscles tire and slightly relax. As soon as the resistance is felt to be lessened hold this position for several minutes and make no further effort to secure additional relaxation at the time. Repeat the manipulation as frequently as possible with gradually increasing force, meanwhile strapping the foot in an over corrected attitude of adduction and inversion and advising appropriate exercises. Where muscle stretching appliances are used the same principles must be used as in manual manipulation. (Fig. 47.)

Cases of restricted tarsal mobility, not the result of muscular spasm or contraction, may be due to several causes. Pronounced malposition of the bones entering into the formation of the longitudinal arch, if long continued, as in flat-foot of long standing, results in changed articulating surfaces, even to the formation of new facets, stretching of the ligaments and fascia and restricted tarsal motion. While such a condition may exist alone it is as a rule complicated by fibrous changes taking place in and about the joints resulting in adhesions which bind the bones together and restrict or obliterate motion in the sub-astragaloid and mediotarsal joints. Again, rigidity may be due to calcareous deposits or the formation of bony spurs or over-growths. Where an inflammatory condition of the joints has existed, or complicates the arch deformity, a fibrosis is always present to some extent with lessened joint function.

In all cases of tarsal rigidity, manipulation must be used to break down the adhesions and restore the bones, if possible, to their normal position. Where the rigidity is very great, accompanied by muscular spasm, it must be done under general anaesthesia. whereby muscular spasm, which is a most important factor in restricted motion, is relaxed and the force exerted directly upon the rigid articulations.

Ordinarily joint adhesions may be relaxed and broken down by systematic and continued manipulation without general anaesthesia. In all cases the manipulation should be preceded by the application of heat for its softening and relaxing effect. Diathermia applied directly through the tarsus is by far the best method and should be continued for at least 30 minutes. If this is not obtainable visible light is the next best modality.

After the tarsal joints are thoroughly heated deep mechanical vibration and concussion should be applied with the foot held in the extreme attitude of adduction and inversion. The vibrator applicator (of hard rubber and disc shaped) should be placed upon the plantar surface of the foot under the inner border of the medio-tarsal joint and powerful upward pressure exerted as the vibrator delivers a deep, strong concussive or vibratory stroke. Following this manual manipulation should be performed in the following manner: With the patient seated in a chair the operator stands before him with the patient's right foot, for example, between his partially bent knees. The fingers of the right hand grasp the heel, holding it straight, while the base of the palm lies against the medio-tarsal joint on the inner and inferior aspect of the foot. The left hand grasps the outer side of the foot and toes. Force is now exerted by the left hand in extending the foot and in the same movement swinging it into an attitude of dorsi-flexion, adduction and inversion while the fingers of the right hand hold the heel steady and its palm pressed against the inner border of the medio-tarsal joint acts as a fulcrum over which the inner border of the foot is bent. This entire movement should be accomplished slowly in an effort to excite as little muscular antagonism as possible and should not be carried to the point of producing extreme pain.

As the involuntary muscular spasm gives way under the steadily applied pressure and with the foot held firmly in this position a series of small, sudden movements, or twitches, is transmitted to the tense joint structure in the direction of pathalogical limitation i. e. in the direction of adduction and inversion. These

movements are developed in the forearm only, the arm and elbow being held pressed to the body and the wrist rigid, and consist of slight, twitching motions produced alternately by the suppinators and pronators of the forearm. This method is nearly always to be preferred to making one or two somewhat violent wrenching movements, as this causes much unnecessary pain and may set up new inflammation. Manipulations of this kind should be frequently repeated, efforts being made to increase the range of motion a little at each operation. Meanwhile the patient should be instructed as to the practice of foot exercises tending to extend, dorsi-flex and invert the foot.

Where joint rigidity is broken up under a general anaesthetic the foot is put forcibly through the entire range of motion after which it is placed in an over-corrected position of dorsi-flexion, adduction and inversion and incased in a plaster of paris cast for several weeks. Frequently it is advisable to divide the tendo Achilles as well as the peronei tendons in such cases and thus secure absolute relaxation of the foot during the period in which it is immobilized. After the cast is removed the leg muscles should be massaged and active as well as passive manipulation resumed for a period of several weeks. Corrective exercises, foot posture and rational foot-gear should be stressed by the operator as an absolute necessity if the regained functions are to be made permanent.

In contrast to the weak-foot with depression of the longitudinal arch we have the hollow or contracted foot in which the arch is exaggerated. This deformity is of two types. In the first class the simple exaggeration of the longitudinal arch is the only change from normal. In the second class the hollow foot is combined with limitation of the range of dorsal flexion, contraction of the plantar fascia, slight inversion of the fore-foot, depression of the metatarsal arch and dorsi-flexion of the toes at the first phalanges. This type of contracted foot is known as "*non-deforming club-foot*" and "*talipes plantaris.*"

It is in this latter condition that manipulation is especially in-

dicated in an effort to relax the contracted calf muscles and thereby increase the range of dorsal flexion. Manipulative procedure is the same as previously described carried to a greater degree. More force must be exerted in dorsi-flexing the foot and for a longer period of time. Especial care must be taken in immobilizing the heel and locking the medio-tarsal joint during the procedure.

The contraction of the plantar fascia may best be treated by deep mechanical vibration applied to the tense tissues of the sole while the foot is held in forced dorsal flexion.

Depression of the anterior or metatarsal arch may be of several types. First, it may be included as one phase of the contracted foot. Second, it may consist of a simple relaxation of the tissues of the fore-foot in which the bones entering into the formation of this, so-called, arch do not regain their arched formation when relieved from pressure, but may be restored to their normal contour by slight manipulation. Third, the depressed arch may be rigid, with hyper-extension of the toes, contraction of the extensor tendons and fibrous changes about the metatarso-phalangeal articulations. Fourth, a depression of only a part of the metatarsal heads may exist; and fifth, a general depression, with arch rigidity, may accompany a pronounced hallux valgus and consequent change in the weight bearing area of the fore-foot. In addition to these conditions depression and rigidity of the metatarsal arch may be due to bony over-growths, traumatism or fibrositic changes following arthritic infections.

With the exception of those cases due to recent inflammatory conditions and the relaxed, flaccid type, just mentioned, manipulation is indicated in all metatarsal deformities and should be preceeded by the application of heat and mechanical vibration. If deep heat is required direct diathermia through the metatarsal region is the indicated method, otherwise radiant light and heat or that produced by the non-vacuum condenser electrode will be found sufficiently relaxing. In vibration as well as manipulation the patient should hold the toes in plantar flexion with the foot

extended. The force exerted by the vibrator should be sufficient to push the metatarsal heads upward as rapid vibratory movement takes place. In manipulating this region the fingers of both hands should be placed upon the dorsum of the fore-foot and extend over the toes, forcing them to plantar flex. The thumbs are applied upon the plantar surface over the metatarsal heads and firm, upward, kneading movements instituted. Each metatarsal head should be manipulated separately and in rotation; in the meantime forcing the toe, or toes, into plantar flexion. This upward pressure should be alternated with lateral stretching of the fore-foot, in an attempt to pull apart or separate the metatarsal heads. This is accomplished by grasping the first metatarso-phalangeal articulation between the thumb and fingers of one hand and the fifth articulation with the other hand in a similar manner and making traction in opposite directions together with alternate up and down movements.

After the metatarsal heads have been manipulated the fingers should be slid up the foot manipulating the shafts of the metatarsal bones with the thumbs and attempting to force them into their normal arched position from below. In metatarsal depression there is a tendency for the bases of these bones to elevate as the heads sink. Consequently at this point in the manipulation the fingers should be forcibly pressed downward upon the bases while the thumbs force the heads upward.

Manipulation of the metatarsus is contra-indicated in acute inflammatory diseases, tuberculous infections of the joints and plantar neuritis.

Preliminary treatment of hallux valgus, whether existing alone or accompanied by a bunion, consists in heating the part to soften the tissues and relax muscular spasm, followed by mechanical vibration. Manipulative movements of a circular character are then produced by the fingers and thumb of one hand grasping the great toe while the fingers and thumb of the other hand hold the metatarsal head in an effort to immobilize it. The direction of

these circular movements should be inward, downward, outward and upward, the force being greatest as the toe is brought inward and downward. Slight traction should accompany the circular movements, which should be concluded by imparting a series of short, jerky, twitches as the toe is held under tension in its most adducted position. These twitching motions should be short and rapid without undue force, the motion originating in the wrist of the operator with the hand held rigid. As hallux valgus is nearly always associated with a depression of the metatarsal arch manipulations directed toward this deformity should also be used. In hallux valgus the fore-foot is always broadened, with a line drawn through the base of the first metatarsal bone falling inside of Meyers line, consequently it is good practice to constrict the metatarsal region by a circular strapping or bandage in an effort to restore the great toe to its normal alignment.

CHAPTER XII

MECHANICAL VIBRATION

Apparatus; Physiological Action; Therapeutics; Technic.

Vibration is one of the most important massage movements but its scientific application is obtained only after long and constant practice. The physical strain following its application is great, resulting in lessened efficiency as the treatment progresses.

Consequently the results obtained by the use of a good mechanical vibrator are quicker, more certain and far more satisfactory.

Apparatus.

An efficient mechanical vibrator should be included in the armamentarium of every chiropodist. It should be so constructed that the range and depth of stroke can be regulated as well as the rate of vibration, which should run from a very rapid, short stroke to a slow, deep, pounding stroke. An instrument developing a true concussive stroke, combined with the vibratory movement, is to be desired. The motor supplying the force should be of sufficient power to prevent stalling when strong resistance is encountered in making deep vibration or concussion. (Fig. 39.)

Applicators are of various types, the following being of especial value in chiropodial work. First, a flat, disc shaped, soft rubber applicator about two inches in diameter for superficial treatment over sensitive or bony parts where a sedative application is desired. Second, a hard rubber applicator of similar shape and size for use over muscle tissue and joints where deep vibration and concussion is necessary. Third, a hard rubber ball-shaped applicator about 1¼ inches in diameter for deep inter-muscular work or where direct, localized pressure is to be exerted, as for instance in vibrating a single depressed metatarsal head.

Physiological Action.

The action of mechanical vibration depends upon the *rate* of

vibration and the *length* of stroke. Rapid vibration with a light stroke inhibits, soothes and is somewhat sedative. The inhibitive effect obtained is no doubt the result of direct action upon the sensory nerve filaments. Rapid vibration with a medium stroke stimulates both nerve action and blood flow. Slow vibration or

Fig. 39
Mechanical Vibrator Capable of Producing
a Deep Concussive Stroke.

concussion with deep, powerful stroke is destructive and relaxing.

Stimulative vibration increases the flow of blood and lymph by its direct action upon the vessels as well as indirectly stimulating the nerve centers. Thus secretion and excretion is increased and

congestion and engorgement relieved. Muscular tone is increased by an improved local metabolism. Local heat is produced.

Deep, slow vibratory impulses soften and relieve muscular contraction by their direct mechanical action, as well as by over-stimulation. Fibrositic deposits are relaxed and softened by the actual application of vibratory force.

Therapeutics.

Mechanical vibration is indicated in all superficial conditions where a gentle effleurage could be used. As a result of the increased blood and lymph flow it relieves muscle tire as well as congestion and engorgement. Superficial swellings about the ankle and foot following long standing, faulty attitudes or improper foot gear subside under sedative vibration. Coldness, mumbness and other sensory disturbances of the feet are benefited by its local application.

As a stimulative measure vibration is indicated to increase the tone of the anterior leg muscles in weak-foot and the latter stages of peripheral paralysis. Contraction of the calf muscles, as well as the peronei, associated with the various deformities of the longitudinal arch may be overcome by deep, relaxing vibration. Rigidity of the metatarsal arch, whether due to adhesions or muscular irritation offers a most satisfactory field for the application of deep vibration and concussion. Ankylosis of the tarsal joints or great toe joint, as well as shortened tendons of the toes, may be relaxed by the use of vibration combined with heat and manipulation. In short the powerful vibratory strokes delivered by a good appliance will accomplish more in rigid and spastic conditions found upon the lower extremity than any other method if correctly applied.

Technic.

In applying vibratory manipulation the following essential points must be borne in mind. To obtain a sedative, soothing effect, use a very rapid, short stroke with but little pressure applied to area under treatment by the soft rubber disc.

Stimulative results depend upon the length of the stroke and the degree of pressure exerted. The length of the stroke is of greater importance than the rapidity. The deeper the tissue the deeper the stroke required. The action of the stroke is increased largely by the degree of pressure exercised by the operator. In breaking down adhesions and relaxing muscle tissue use deep, localized pressure continued for several minutes, shifting the applicator from point to point.

Always move the applicator toward the body, never back and forth. In sedative vibration start well above the part and begin each upward stroke below its predecessor until the actual area to be vibrated is reached. In all cases it is well to precede vibration with some form of heat. Ankylosis or rigidity of the ankle or tarsal joints demand diathermia, while visible light or the non-vacuum electrode will furnish sufficient heat to relax contracted muscles except in obstinate cases. In the metatarsal region visible light is the best and quickest form of heat to use, unless the part is particularly sensitive and painful, in which case use through-and-through diathermia. In chronic bunion or hallux valgus localize the area by wrapping a towel about the fore-foot, exposing only the joint to the visible light rays. Should deeper heat and relaxation be required use diathermia.

In vibrating a rigid, or partially rigid joint, always hold it in the position in which the motion is most limited. In other words put the tissues upon the stretch in the direction in which you desire increased motion. Apply the applicator gently at first, gradually increasing the pressure until the entire joint is receiving a series of slow, deep seated vibrations or concussions.

In rigid weak-foot localize the vibrations upon the inner and inferior border of the medio-tarsal joint, just under the tuberosity of the scaphoid. Before concluding the treatment carry the vibrator applicator transversely across the foot and vibrate the area beneath the cuboid, making strong upward pressure. During the entire treatment the foot should be held tense in forced adduction and inversion.

Vibration of the metatarsal arch should be accomplished by using the flat, hard rubber disc just back of the metatarsal heads. Deep, slow strokes may be produced by making strong upward pressure. The position of the applicator should be constantly changed so as to include all the joints in the operation. While this is being done the toes should be held in firm plantar flexion. If special rigidity exists in one or more of the metatarsal joints vibration may be localized and intensified by using the hard rubber ball applicator. After vibrating the plantar surface put on a soft rubber disc and while the toes are firmly plantar flexed vibrate the dorsum of the foot over the contracted extensor tendons for several minutes.

In vibrating the great toe joint in the treatment of bunion or hallux valgus forcibly adduct the toe and gradually produce strong, slow vibrations while it is held in this position. The applicator should be placed alternately under and back of the first metatarsal head while this is being done. After a minute of strong, deep vibration adjust the instrument so that it will deliver a short, rapid stroke and go over the entire enlarged area in a circular manner. A soft rubber disc should be used about the great toe joint.

As depression of the metatarsal arch usually accompanies chronic bunion it is usually necessary to vibrate and manipulate it as well as the great toe joint. Treatment should be concluded by applying a cut-out half-moon shield, points down, over the enlarged joint and reducing the circumference of the fore-foot by a circular strapping.

To secure relaxation of the calf muscles vibration should start at the lower portion of the leg and be carried upward, using deep, slow, concussive strokes applied with a hard rubber disc or ball applicator. While this is being done the foot should be held in dorsi-flexion and the calf muscles steadied by the fingers of one hand in order to secure the full force of the stroke. This treatment should consume at least five minutes and should be preceeded by some form of heat. In vibrating the anterior leg muscles employ

a soft rubber disc with medium pressure and rapid vibratory movement, the object being to stimulate rather than relax.

Chronic ankle sprains are much benefited by stimulative vibration while acute sprains may be vibrated immediately in an effort to lessen pain and swelling. A mild, slow stroke should be used.

CHAPTER XIII

HYDROTHERAPY

By Hydrotherapy is meant the application of water in various forms to the surface of the body for the modification of physiological and pathological processes. If the application is made in the form of a still bath or pack it is simply one method of applying conductive heat or cold. If on the other hand the water is forced against the part or is made to circulate about it the result is obtained by mechanical as well as thermic means.

Water absorbs heat or cold very rapidly and gives it up as quickly to bodies with which it is in contact, and for this reason may be considered an ideal medium for the application of external heat or cold.

Heat and cold are relative terms. Objects are recognized as cold when they have a temperature less than that of the skin (about 93°) and warm or hot when they are above the skin temperature. In hydrotherapy the following temperature classification is generally used:

Very cold	32° to 55°	Fahrenheit
Cold	55° to 65°	"
Cool	65° to 80°	"
Tepid	80° to 92°	"
Warm ....(neutral 92° to 95°)	92° to 98°	"
Hot	98° to 104°	"
Very hot	104° and above	"

Physiological Action.

When a cold application is made to the body the first effect is a lessening of the activities of the structures with which the cold comes in contact. If the application is continued for a long time the depression continues, being maintained for a time after the removal of the cold application, but sooner or later the parts return to their normal condition and if the depression has not been too great or too long continued a state of increased vital activity fol-

lows, which is higher than that existing prior to the application of cold. This increased physiological activity is termed "reaction." The shorter the application of cold the quicker the reaction. Thus temperatures below that of the skin are primarily depressant and secondarily stimulative. The reaction to cold is more marked than that to heat.

A short application of cold or very cold water produces pallor and coldness of the skin due to the contraction of the skin capillaries and a dilitation of the deeper lying blood vessels. When the application ceases the skin becomes red due to the active dilitation of the small arteries of the skin. This is the so-called reaction.

Cold slows the circulation, not only in the area exposed but in distant parts and viscera as the result of reflex action. Prolonged applications of cold water decrease muscular irritability and muscular energy. A short cold bath, as a douche or spray, lasting for a few seconds augments muscular energy and tone to a marked degree. While cold decreases the irritability of voluntary muscles it increases the activity of involuntary muscle tissue. This is demonstrated when the foot is placed in cold water and "goose flesh" appears not only upon the leg under treatment but upon the whole body, as the result of contraction of the involuntary muscular fibres of the skin.

Muscular stimulation, if not contraction, may be produced by cold applications, especially at high pressure, upon reflex areas. This is especially marked in the application of cold to the plantar surface of the foot, the reflex action producing a tonic effect upon the leg and thigh muscles.

The application of hot water (100° to 104°F) reddens the skin as a result of stimulation of the vaso-dilators with paralysis of the vaso-constrictors. Dilation is not only of the arteries but of the small veins and lymph channels. Primary stimulation is followed by secondary depression.

The sensibility of the skin is greatest from 95° to 98°F, or the normal temperature of the body, while very hot applications (108°

and upward) lessen skin sensibility. Thus the alternating, or Scotch douche, is of marked benefit in the treatment of neuralgic pains.

Prolonged applications of water at a temperature above 100°F diminish muscular excitability and capacity for muscular work. Very long applications of heat not much above the normal body temperature produce muscular weakness. On the other hand very short, hot applications are the best means to counteract muscular exhaustion due to prolonged exercise. This is probably due to the elimination of fatigue poisons as well as reflex stimulation of the nerve centers.

The results secured by hot baths are increased by the application of short, cold applications, such as a cold douche or shower for 3 or 4 seconds. To secure the maximum of restorative results the hot bath should not last more than 5 minutes.

Excessive muscular irritability, as cramps or muscular spasm, is quieted by a prolonged neutral bath at a temperature of from 92° to 95°F.

Hot baths are excitive or exhaustive to the nervous system according to the mode of application. An application may excite at first and then depress. The effect of a neutral bath is to diminish nervous irritability, thus producing a sedative effect.

Application.

The **Hot Foot Bath** should begin at a temperature of 102° to 104°F and be gradually increased until by the end of 2 or 3 minutes a temperature of 115° to 122° is reached. This temperature should be maintained from 5 to 15 minutes. The feet should be completely immersed in water; the effect being intensified by increasing the depth of the bath. In treating weak-foot the water should come well up the leg. After the very hot foot bath the feet should receive a douche or spray of cold water to produce the revulsive effect by suddenly cooling the skin and encouraging tonic circulation.

The hot foot bath produces general as well as local effects. At first the pulse rate is slowed, later increased. Body temperature is

increased. By the dilitation of the vessels of the legs congestion is relieved in the upper portions of the body. Very hot (115° to 125°F) applications stimulate the involuntary muscles of the abdominal viscera. The very hot foot bath is exceedingly useful in sprain of the ankle joint. Anaesthesia of the plantar as well as the dorsal region and neuralgic pains of the foot are relieved by a very hot foot bath. The application should be made two or three times a day and continued from 20 to 30 minutes. The prolonged warm or hot foot bath (98° to 106°) dilates the vessels of the feet and reduces the supply of blood to the abdominal organs.

The **Cold Foot Bath** though less useful than the hot foot bath is of service in producing reflex, revulsive effects. The sole of the foot is one of the most important vasomotor areas in the body, having very direct connection with the nerve centers which control the circulation of the abdominal organs.

The temperature of the water in the cold foot bath should be from 45° to 55°F and the application should be continued from 1 to 5 minutes. From 3 to 4 inches of water should be used and the feet should be warmed before placing in the bath. While in the bath the feet should be vigorously and continuously rubbed or massaged.

The effects secured by a cold foot bath continue for a longer time than those produced by a hot application. In coldness of the extremities and persistent sweating the rubbing cold foot bath (50° to 60° F) is indicated as a means of securing circulatory reaction. It should be used from 1 to 3 minutes and repeated daily. The prolonged foot bath may be used as an antiphlogistic measure in strains and sprains, as well as inflammed bunions and bursae. The feet must be warmed by rubbing before placing in the bath. A shallow cold foot bath may be used where a more intense circulatory reaction is desired. The water should be very cold (45° to 55°F) and barely enough placed in the tub to cover the toes. After being in the water for one-half a minute the foot should be taken out, rubbed briskly and then returned to the water. The

other foot is then treated in a similar manner; this should be continued until a strong circulatory reaction is secured.

The **Alternate or Contrast Foot Bath** consists in applying the foot, or the foot and leg, in hot water for 2 or 3 minutes, then in cold water for 20 or 30 seconds. It is then returned to the hot water for 2 minutes and again replaced in the cold water. This is repeated a number of times. The alternate hot and cold foot bath is more highly stimulative than the cold foot bath and is the most useful method for chiropodial work where stimulation is desired. It is especially indicated wherever decided vasomotor reactions would be of benefit, as chillblains, cold extremities, swelling due to impaired circulation and hyperidrosis. As a tonic measure in the early treatment of weak-foot it may be used to advantage in connection with other physiotherapeutic methods.

The **Whirlpool Bath** consists of a special tub in which the water is kept in motion during the bath, thus securing the stimulative mechanical effects produced by the moving water as well as the thermic action. Pipes carrying hot and cold water are so placed that their discharge creates rapid cross currents or whirls of water. Compressed air is also forced in with the water increasing the force and direction of the flow. The whirlpool bath is given by placing the limb in the bath, starting at a skin temperature (about 93° F) and raising the temperature gradually to the point of tolerance for 15 to 30 minutes. The heat plus the friction developed by the flow of water and bubbles against the skin produce a sedative result.

The **Paraffin Bath** consists in melting paraffin in a specially constructed double boiler large enough to accomodate the leg or arm. A higher degree of heat may be tolerated by this method than by hot water. From 125° to 130° F can usually be borne by the foot. Treatments may be continued from 15 to 30 minutes. As the foot is placed in the hot bath a film of paraffin cools and solidifies upon the skin, thus preventing perspiration and heat radiation as well as reducing to a degree the conduction of heat.

CHAPTER XIV

CORRECTIVE EXERCISES

As acquired weak-foot and flat-foot is due to faulty posture in standing and walking and as foot posture is controlled by the muscles, principally by those of the leg, it is quite evident that any treatment which fails to include corrective foot exercises is not only incomplete but unscientific, in that it overlooks the primary cause of the deformity.

Corrective exercises, properly performed for a sufficient length of time, plus footgear adapted not only to the anatomical structure of the foot but to the individual type as well, will cure ninety percent of early weak-foot cases in young individuals.

In treating arch deformities it is the duty of the chiropodist to stress these facts and educate the patient as to the normal functions of the foot as well as to direct corrective exercises. The patient should be instructed to hold the feet parallel in standing and walking, the body erect, head thrown back and chest forward. In walking the feet should be used as levers, the ankle joint acting as the fulcrum and the muscles as the source of power. The heel should only be touched to the ground momentarily and as the body inclines forward the weight is thrown over the ankle joint and delivered respectively to the bones of the tarsus, metatarsus and phalanges, which by their arrangement form the long and flexible end of the lever. Locomotion should be elastic and springy, the greater part of the motion being carried out by the flexible forefoot; not flat-footed and slouching with the heel upon the ground and one foot being pushed past the other with bent knees and everted toes. Instruct the patient to swing forward upon the ball of the foot and finally as the weight is carried by the toes to press down upon the sole of the shoe, gripping the ground with the toes. In ascending stairs place only the ball of the foot upon the stair tread, lifting the body by the contraction of the calf muscles.

In standing avoid particularly the attitude of abduction or pronation. The feet should be held "four square," not as a triangle. As a standing base the area of a square is far greater and more stable than that of a triangle. Long continued standing in the passive attitude should be discountenanced inasmuch as in standing the muscles are inactive while the ligaments of the foot bear

Fig. 40
Exercise No. 1.

practically all the weight; while in walking the active muscles carry the strain and the inelastic ligaments are relieved. When necessary to stand for long periods instruct the patient to rise up and down upon the ball of the foot frequently and thus shift the body weight from one structure of the foot to another.

In the sitting posture the feet should be crossed, resting upon their outer borders. This attitude is specially indicated in children exhibiting congenital weak-foot.

Exercises to develop Longitudinal Arch.

1. Place the feet side by side in an attitude of slight adduction. Rise *slowly* upon the tip-toes while ten is being counted, keeping the legs extended and parallel and the body erect. When the extreme height has been reached hold this tip-toe position while ten is again counted. (Fig. 40.) Sink slowly and gradually upon

the outer border of the foot, which is turned at the ankle in the attitude of inversion. This is the most difficult part of the exercise and should consume at least 8 or 10 seconds. This, as all other foot exercises should be performed in the bare or stockinged foot. It is the most important of all foot exercises directed to the correction of longitudinal arch deformity and should be repeated 20

Fig. 41
Exercise No. 3.

times twice a day, gradually increasing to 50 or 60 times. Where contraction of the calf muscles exist this exercise must be accompanied by exercises No. 5 and 6, and where metatarsal depression exists include exercises No. 7 and 8.

2. Place the feet parallel, slightly separated, rotate the legs outward and make the inner borders of the feet concave without raising the soles from the floor. Hold this position for 10 seconds. This is also a longitudinal arch exercise as well as the following:

3. Stand feet parallel, roll upon outer borders of the feet, legs held straight and the toes flexed. (Fig. 41.)

4. With one leg crossed over the other describe a circle with the fore-foot (Fig. 42) the greatest direction of force being exerted

from without inward, in an effort to adduct and invert the foot strongly. The foot should be slowly flexed and extended as the circular movement continues. This exercise is especially adapted to very young children who learn to follow with their fore-foot the circular motion described by a guiding finger. Children may also be taught to walk upon the outer border of their feet, or pigeon-

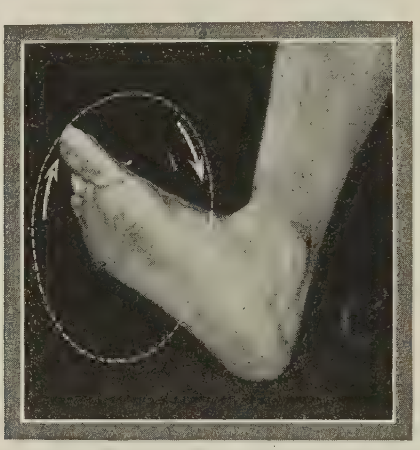

Fig. 42
Exercise No. 4.

toed, or to walk a crack in the floor, all of which tend to correct the abduction and eversion so noticeable in the congenital weak-foot.

Exercises for the Relaxation of Contracted Calf Muscles.

5. Take a long step forward with one foot, bend the knee of this leg and incline the body forward as far as possible without *lifting the heel of either foot from the floor* or bending the knee of the extended rear leg. When this movement has reached its extreme degree the tension upon the calf muscles of the extended rear leg will be apparent. This attitude should be held for 10 seconds. Reverse the position of the legs and repeat several times, first with one leg and then with the other. The toes of each foot should be pointed straight ahead while performing this exercise.

6. With feet parallel and pointing directly forward stand from three to five feet from a wall (depending upon the height of the individual), extend the arms, incline the body forward and fall toward the wall, supporting the inclined body upon the outstretched arms. With the *legs fully extended and both heels upon*

Fig. 43
Exercise No. 6.

the ground flex the arms at the elbow allowing the body to incline still further toward the wall and exerting a powerful tension upon the calf muscles. Hold this position for 2 or 3 minutes, rest and repeat.

Metatarsal Exercises.

7. Attempt to pick up a small rounded object, as a marble or hickory-nut, with the flexed toes, or make an effort to grasp and hold the edge of a rug with the toes. Exercise each foot alternately for several minutes.

8. Stand upon a stool, book or box and attempt to grip its edge with the flexed toes (Fig. 43.) Hold this position for at least one minute, rest and repeat several times.

CHAPTER XV

CLINICAL APPLICATION

In considering the application of the various physio-therapeutic measures certain facts should be accepted; first, that nothing spectacular is accomplished by their use, results being attained gradually after frequent treatments. Just as a single, or infrequent, dose of medicine would not be expected to cure a disease, so a single or widely separated series of physio-therapeutic treatments must not be expected to accomplish miracles. Second, many of the chiropodial, and most of the orthopedic conditions, are sub-acute or chronic in character, exhibiting radical tissue change and deformity. Consequently no therapeutic agent can be expected to produce immediate results. Again, physio-therapy is, in a sense, a last resort. After a condition is operated, dressed, bandaged or treated by the application of medicaments and no results have been obtained we are forced to fall back upon physical measures, nature's remedies, and it is illogical to expect them to work wonders. However, if scientifically used and carefully selected the various modalities will accomplish certain definite results which are not obtainable in any other manner. Third, close attention to detail and technic is imperative, the improper placing of an electrode, or even its faulty attachment to a conductor cord is sufficient to prevent successful results.

The manipulation of electro-therapeutic apparatus consists in something more than simply throwing a switch. Skill, brains and intelligence, with a liberal sprinkling of "hoss sense" are as necessary in the practice of physio-therapy as any other branch of medicine.

In the following pages the etiology and pathology of the various deformities and diseases will be briefly considered inasmuch as treatment can not be intelligently instituted unless the cause as well as the pathological changes are known. The therapeutic indications are based upon the pathology of the condition and may

frequently be met by the use of various modalities exhibited in various ways. The treatment outlined is the outcome of practical experience and usage, but in no sense must be taken arbitrarily. In all cases treatment must be adapted to existing conditions and requirements and upon the skill and ingenuity of the operator to meet these depend the results attained.

Fig. 43A

One Method of Applying Diathermia to Both Feet and Legs. The Current Is Short-Circuited by Clipping the Two Block-Tin Cuffs to a Short Connecting Wire. Note Position of the Distal Electrodes in Water Bath. This Technic May Be Used Where General Heating of the Tissues of the Leg and Foot Is Desired, as in Peripheral Nerve Lesions, Neuritis, Arthritis, Sprains, Synovitis, Vascular Conditions, Weak-Foot, etc. This Hook-Up May Also Be used in the Application of the Sinusoidal Currents to the Feet and Legs.

Deformities of the Arches of the Foot.

Weak-foot.

Synonyms. Flat-foot; splay-foot; pronated foot; pes planus; fallen, broken or dropped arch; fallen or broken instep; weak ankle.

Definition. Weak-foot is a disability characterized by the persistence of the attitude of abduction and comprises all arch strain of static origin. The general term "weak-foot" is used to indicate all types of disability caused by improper functioning of the foot. A weak-foot is not necessarily a flat-foot, for the longitudinal arch is not flattened in the earlier cases, and in those later cases in which it does occur the deformity may exist only under weight bearing. A **flat-foot** is a flattened out weak-foot, in which the deformity is constant and consequently will simply be considered as a more advanced type of weak-foot.

Types of Weak-foot.

1. **Strained foot** is the initial response of the soft tissues to abnormal functioning of the foot in standing and walking, resulting in tire and weakness with normal voluntary motions. *The normal foot improperly used.*

2. **Incipient weak-foot** is the first evidence of abduction and eversion of the foot in reference to the leg. Actual depression of the longitudinal arch may or may not exist. Voluntary movements are normal.

3. **Simple, Relaxed Weak-foot** is that attitude of deformity in which the longitudinal arch is abnormally depressed upon weight bearing, but regains its normal contour when pressure is removed. The range of normal motion is somewhat limited, particularly dorsal flexion and adduction. Forced motion causes discomfort.

4. **Flattened-out Weak-foot** (flat-foot, acquired or vocational) is that attitude of deformity in which the arch is abnormally depressed or obliterated and does not regain its normal curvature when relieved from weight bearing. The range of both voluntary and passive motion is much restricted, particularly the motions of adduction, inversion and dorsi-flexion.

5. **Rigid Weak-foot** is that fixed deformity caused by muscular spasm *(Spastic Weak-foot)* or secondary changes in the foot structure, which may be bony or fibrous. The range of normal motion is much restricted, while adduction and inversion is usually obliterated. Voluntary and passive motion painful.

6. **Congenital Weak-foot** (Flexible flat-foot in children) is that attitude of deformity in which the longitudinal arch is greatly depressed or obliterated upon weight bearing, returning to its normal position when relieved from pressure. Voluntary and passive motions free, normal and painless.

Fig. 43B

Another Method of Treating Both Feet and Legs by Diathermia. The Terminals Being Clipped to Cuff Electrodes About the Calves While the Feet Rest in a Saline Water Bath. **The Feet Must Not Be in Contact.** This Hook-Up Is Also Valuable in Treat'ng the Feet and Legs by the Rapid Sinusoidal Current.

7. **Congenital Flat-foot** (Pes Planus) is that deformity in which the flattened foot exists from birth, the *posture* and *motions* of the foot being *normal*. Apparently characteristic in certain races.

8. In addition to the various static types, weak-foot and flat-foot may result from injury *(Traumatic)* or paralysis *(Paralytic)*. The former may be relaxed or fixed, depending upon the nature of

the injury; while the latter is usually a relaxed deformity.

Etiology.

Weak-foot is caused by improper functioning of the foot, i. e., abduction and eversion in standing and walking. Any condition which may excite or predispose such an attitude may logically be considered a cause. The following are the most common:

1. Long continued standing. 2. Excessive weight bearing. 3. Improper foot-gear. 4. Sudden changing from high to low heeled shoes or vice versa. 5. Shortened calf muscles. 6. Deformities of the foot, hallux valgus and depression of the metatarsal arch. 7. General weakness, as that following acute infectious diseases. 8. A weakness of the muscles and ligaments of the foot and leg, existing from birth, as found in congenital weak-foot. 9. Diseases of the bones and joints. 10. Trauma. 11. Paralysis.

Symptoms.

The symptoms of weak-foot vary with the degree of deformity, habits and susceptibility of the individual. In early strained-foot there is a sensation of weakness, tire and discomfort along the inner side of the foot, frequently extending up the calf to the knee, and even to the thigh, hip and lumbar region. These leg and back pains are more often found in women, and especially after long periods of standing. Their onset is usually gradual but severe strain or exertion may bring on an attack.

As the condition progresses and the arch begins to relax the characteristic posture becomes apparent, the foot losing some of its elasticity and more weight being borne upon the heel, giving rise to pain in the center of the heel as the result of the jarring walk and the stretching of the plantar tissues. The discomfort along the inner side of the foot increases and is localized at the inner border of the medio-tarsal joint, while tenderness and swelling is found upon the dorsum of the foot below and in front of the external malleolus. These early cases are relieved by rest and freedom from weight bearing, but reappear as the foot is used. As a result of the weakness and impaired circulation the foot is frequently

swollen over the dorsum, cold, numb, congested, bathed in perspiration. It looks "tired."

As the condition progresses the foot bulges inward, broadens and flattens until the longitudinal arch is permanently obliterated. The patient stands with feet rotated outward and walks "flat-footed" with little spring or ankle movement, the normal range of motion is limited and forced motion more or less painful. If the process continues to the point of rigidity the flattened foot is fixed in abduction and eversion, the weight being carried by the heel and the feet being pushed by one another with the knees bent.

Pain, swelling and muscular spasm occur as the inflexible foot is subjected to constant shocks and inequalities of the surface walked upon, while acute pain is experienced upon using the foot after a period of rest. Passive motion is painful and difficult. It is not unusual for a sufferer to complain of rheumatism and be treated for that condition.

Mechanics of Weak-foot.

The mechanical changes in weak-foot are the result of improper attitudes in standing and walking, i. e., the foot abducted and everted, and may be analyzed as follows:

1. The leg is displaced and rotated inward so that the weight is thrown upon the inner side of the foot and the line of body weight falls inside the great toe, instead of through the center of the foot.

2. As a result of the changed line of weight bearing the upper and inner portion of the os calcis tilts inward carrying with it the astragalus whose head, rotating, slips downward and inward, forcing the scaphoid in front of it, which in turn forces the three cuneiforms downward and inward, resulting in a rolling inward or a general depression and bulging of the inner side of the foot.

3. The cuboid follows the changed position of the os calcis, rotates upon its long axis and approaches the ground, lowering the outer segment of the arch.

4. As the tarsus rolls inward and flattens the fore-foot is still further abducted increasing and repeating the vicious circle.

Thus the whole foot is twisted and weakened, the ligaments of the ankle and inner side of the foot are weakened and stretched while the adductor muscles relax and tire in their effort to overcome the abnormal posture and in doing so allow the foot to swing still further outward.

Fig. 43C

Through-and-Through Diathermia for the Relaxation of Contracted Calf Muscles or Other Affections of This Location. The Lateral Block-Tin Electrodes Are Held in Place by Adhesive Plaster Strips in Order to Show Position of Plates and Attachment of Clips.

Treatment.

In the treatment of weak-foot three objects are to be attained. First, to correct faulty attitudes in standing and walking. Second, to establish the normal range of motion, or as near normal as possible. Third, to elevate and support the arch, or in early cases

to prevent arch depression. It is in the first two objects that physio-therapy is indicated.

Strained foot, Incipient and Simple, Relaxed Weak-foot should receive tonic and stimulative treatment in an effort to tone up the weakened muscles of adduction and dorsi-flexion, to relax any muscular contraction which may exist in the calf and abductor muscles and relieve the general symptons of foot strain and impaired circulation as evidenced by pain, coldness and numbness, congestion and increased perspiration.

Visible light is the best modality with which to stimulate the general circulation of the foot and leg in these cases. It should be used to its full intensity for 5 to 10 minutes or until an active hyperemia is produced. This should be followed by gentle stimulative massage to the anterior muscles of the leg and a stroking sedative massage to the foot. Mechanical vibration may be substituted for massage in which case a short, rapid vibratory stroke should be used over the anterior leg muscles and a deeper, slower stroke directed upward and outward at the inner border of the medio-tarsal joint. Where contraction of the calf or abductor muscles exists it should be relaxed by visible light or diathermia, deep massage or relaxing vibration and manipulation *before* treating the muscles which adduct and dorsi-flex the foot.

In the absence of visible light or diathermia the high frequency current applied by means of the non-vacuum condenser electrode may be used to increase the circulation and stimulate local metabolism. A hot foot and leg bath (100° to 104° F.) for five minutes followed by a momentary cold douche will be found extremely beneficial in toning up the tissues of the leg and foot and ridding them of fatigue products. It may be used in place of visible light or other heating applications. The revulsive effect secured by the cold douche is readily obtained by spraying cold water or alcohol upon the leg and foot by means of an air compressor or hand atomizer.

Physio-therapeutic treatment should be brought to a close by

an application of the slow sinusoidal or surging sinusoidal current for five minutes. The strength of the current being sufficient to produce slight visible contractions of the leg muscles which may be secured by placing the feet upon separate foot plates or in separate foot baths, the terminals from the sinusoidal apparatus being connected to the foot plates, or dropped into the saline solution of each foot bath.

A longitudinal adhesive plaster strapping should be applied in an effort to correct the foot posture as well as to take the strain off the arch. Corrective exercises and raising the inner border of the heel and sole of the shoe should be directed. Treatment should be repeated every fourth or fifth day.

Flattened Weak-foot (Vocational or Acquired Flat-foot) is attended with visible flattening of the longitudinal arch, marked lessening of the motions of adduction and inversion and usually limited dorsi-flexion due to contraction of the posterior leg muscles.

Treatment should follow the lines just laid down only to a more energetic degree. The contraction of the abductors and gastrocnemius should be overcome by a longer application of visible light or diathermia followed by a deep vibration and strong stretching manipulations as well as vigorous manipulation of the longitudinal arch in the direction of adduction and eversion. The anterior leg muscles should be stimulated by vibration and massage movements and lastly the slow sinusoidal current should be used to the point of securing moderate contraction of the tibialis anticus and extensor longus digitorum muscles for five minutes. In using the slow sinusoidal current the electrodes should be placed over the popliteal space and the *motor points* of the muscles named, or over their point of origin and insertion. (Figures 44, 45, 46).

The high frequency current applied by means of condenser electrodes or hot foot baths may be used to advantage upon the foot where pain, tenderness and swelling is marked.

Longitudinal strappings are to be applied and corrective exer-

cises as well as shoes with the Thomas or extension heel, raised one-fourth of an inch upon the inner border, directed.

Rigid Weak-foot due to spasticity of the calf and abductor muscles (Spastic Weak-foot) requires the application of sufficient heat to relax the contracted muscle tissue. This may be secured by using visible light directed upon the calf muscles for 15 min-

Fig. 43D

Diathermia of the Metatarsal Region by Means of Dorsal and Plantar Plates Held in Place by Elastic Bandage. Noté Attachment of Clips. These May Be Reversed as the Treatment Progresses Resulting in a "Cross-Firing" of the Area under Treatment. This Technic Is Used in the Treatment of Metatarsalgia, Morton's Neuralgia, Arthritis, Ankylosis, Fibrosis and Rigidity of the Tissues in and about the Metatarso-Phalangeal Joints.

utes, or better, diathermia applied by lateral plate electrodes upon either side of the calf muscles, or cuff electrodes upon the leg, for the same length of time. This should be followed by deep, relaxing vibration and forced manipulation tending to overcome the contraction of the peronei and gastrocnemius muscles. *After* this has been done the anterior leg muscles should be stimulated by

massage, vibration and the slow sinusoidal current applied directly to these muscles.

These cases should be strongly strapped in an over-corrected position of adduction and inversion and the soles and heel of the shoes should be raised one-quarter of an inch upon their inner border. Corrective exercises directed toward dorsi-flexion, adduction and inversion should be prescribed. Tip-toe exercises being contra-indicated.

Rigid Weak-foot due to fibrous or osseous changes within the joints as well as changes in the articulating surfaces should be x-rayed in an effort to clear up the extent and nature of the joint changes. In those cases due to fibrosis the first indication consists in the employment of the diathermia current in an effort to secure its absorptive and softening effect upon the fibrous adhesions in and about the medio-tarsal and sub-astragaloid joints. A direct through-and-through action should be obtained by the application of the diathermia electrodes as previously described under the subject of diathermia. Treatment should continue from 30 minutes to one hour and is frequently followed by a brief application of the rapid or interrupted rapid sinusoidal current in an effort to stimulate the absorption of the softened fibrosed tissue. Negative galvanism is also frequently used to follow diathermia for its distinctive softening action, the electrodes being placed upon either side of the fibrosed joint and frequently wet with a solution of sodium chloride or potassium iodide in an effort to secure chlorine or iodine ionization.

Following these measures deep massage or powerful vibration and percussion is applied for the relaxing effect after which the joint is manipulated in an effort to increase the range of motion.

Treatment should be repeated twice a week, the foot being supported by an adhesive plaster strapping in an adducted and inverted attitude in the meantime. Any treatment directed to the restoration of tone in the leg muscles must be of mild degree until the rigidity of the foot is relaxed and the joints capable of at least partial function. When this has been accomplished the leg

muscles may be stimulated to increased activity by heat, massage and the exercising slow sinusoidal current.

Congenital Weak-foot. This condition found so frequently in childhood and at the age of adolescence is evidently a foot manifestation of general weakness and disability. The symptoms are those of deformity under weight bearing, the shape and conformation of the foot being practically normal when not in use.

In these cases systematic application of the muscle exercising currents, i. e., the slow and surging sinusoidal modes, with massage and corrective exercises will do much to increase the strength of the leg muscles and restore foot posture under weight bearing. However, it must be remembered that these treatments will be necessary throughout several years and that the foot must meanwhile be assisted to maintain a correct posture as well as receive the support afforded by a scientific appliance. For these cases no support embodies the corrective principle of the Whitman brace.

Traumatic and Paralytic Weak-foot. The treatment of traumatic weak-foot must of necessity depend upon the character of the deformity, which may be relaxed or rigid. Where fibrous adhesions fix the joints of the tarsus the treatment would be along the lines just laid down for the treatment of rigid weak-foot. If the injury results in a relaxed and depressed arch the treatment will, as a rule, consist in supporting the foot with a well fitting arch plate, inasmuch as the deformity is localized in the bony structure and not the result of functional inactivity.

The treatment of paralytic weak-foot consists in an attempt to restore function in the muscles paralyzed or partially paralyzed. The nature of the disease or traumatism producing the peripheral paralysis, the extent of the lesion and its duration will influence the treatment and prognosis. The general treatment would be that described under peripheral paralysis.

The Hollow or Contracted Foot.

Types of Hollow Foot.

The hollow foot may consist simply of an abnormally high longitudinal arch (talipes arcuatus) without accompanying de-

formity in other foot structures. More frequently it is associated with lessened dorsi-flexion as the result of contraction of the calf-muscles, depression of the metatarsal arch and contraction of the plantar fascia. This type is known as "talipes plantaris", "non-deforming club-foot" and the contraction of the calf muscles as

Fig. 43E

Method of Developing Heat through the Tarsal Region by Diathermia. The Block-Tin Plate Electrodes Are Applied over the Inner and Outer Borders of the Medio-Tarsal Joint and Held Smoothly in Contact by Elastic Bandage. This Technic May Be Used in Treating Rigidity of the Mid-Tarsal Joint as Found in Rigid Weak-Foot, Chronic Sprain, Arthritis, etc.

"right angular contraction of the gastrocnemius", due to the fact that the foot can not usually be dorsiflexed to an angle less than 90 degrees.

Etiology.

The simple hollow foot is usually an inherited peculiarity although the deformity may be exaggerated by the use of high heeled shoes or the excessive use of the calf muscles as in toe

dancing. The second variety is most commonly caused by the use of high heeled shoes, with disuse of the muscles dorsi-flexing the foot and consequent contraction of the calf-muscles. (Approximately 25 per cent of adult females that apply for foot treatment exhibit well marked shortening of the calf-muscles). Where contracted foot exists from childhood it is quite possible that it has been caused by one of the acute infections which weaken or paralyze the anterior leg muscles causing more or less of a toe-drop with contraction of the plantar fascia and posterior muscles of the leg. Later in life this condition may follow an attack of neuritis, rheumatism or a fracture or sprain of the ankle.

Symptoms.

Simple hollow foot usually presents no outward symptoms. In the acquired form the gait is ungraceful and stumbling, the feet being abducted and the weight borne upon the heels and balls. The plantar fascia is tense and frequently sensitive to touch and the metatarsal arch depressed and rigid with toes fixed in dorsi-flexion. Corns and calluses exist under the heads of the metatarsal bones. The patient complains of pain in the heel and sole of the foot and inability to use the foot without tiring and fatigue. Pain upon the outer dorsal surface, with swelling, is a frequent symptom as well as pain and cramping of the calf-muscles, the pain being referred to the posterior knee joint or thigh.

Treatment.

The essence of the treatment in these cases consists in a relaxation of the contracted calf-muscles, stimulation of the dorsal flexors, elevation of the metatarsal arch and stretching of the shortened tendons dorsi-flexing the toes, with the application of a foot plate which will distribute the body weight uniformly from heel to ball.

Early in the treatment all efforts should be concentrated upon relaxing the contracted calf-muscles. These should consist in using visible light or diathermia, from 15 to 30 minutes, over the calf of the leg and the sole of the foot, followed by deep massage or vibration and percussion in an effort to soften and relax the heated

muscle tissue. The foot should then be forcibly manipulated as directed in Chapter eleven and a longitudinal strapping applied while it is held in extreme dorsi-flexion and adduction. Manual manipulation and stretching may be replaced by mechanical muscle stretching accomplished by means of a Zander or Schuster appa-

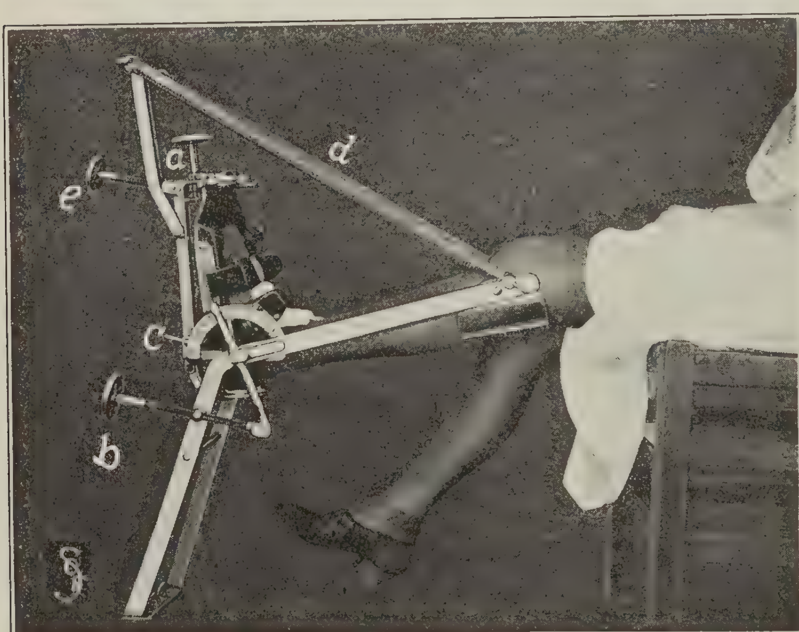

Fig. 43J

Schuster's Apparatus for Stretching the Calf-Muscles.
a. Ratchet for Forcing the Foot into Inversion to Lock the Midtarsal joint.
b. Screw to Control Action of Springs.
c. Dial, Registering Degrees of Flexion.
d. Springs That Supply Force for Stretching.
e. Screw to Increase Pull of the Springs.
(From "Foot Orthopaedics" Published by The First Institute of Podiatry.)

ratus (Figure 43J). The height of the heel should be *gradually* lowered. This may be attained by prescribing a low heeled shoe (1 or 1¼ inch) in which a heel cushion (¼ to ½ inch) is placed and gradually thinning this elevation until the heel is in contact with the insole. Calf-muscle stretching and metatarsal exercises should be directed and insisted upon. Tip-toe exercises are absolutely to be avoided.

As the treatment continues and the patient is able to dorsiflex the foot to a greater degree stimulation of the anterior muscles may be begun by using gentle massage or light, rapid vibration, followed by a mild, slow sinusoidal current applied directly to the adductors and dorsal flexors for 5 minutes. Manipulation of the metatarsal arch, with forced plantar flexion of the toes, should also take place after relaxation of the metatarsal region is secured by moderately deep vibration and percussion.

Continued relaxation of the calf-muscles justifies more stimulative treatment of the anterior leg muscles, in which the slow sinusoidal current may be used in sufficient dosage to produce strong contraction of the tibialis anticus and extensor longus digitorum. All corrective exercises, with the exception of those in which the the body weight is carried upon the tip-toes, should be continued and shoes with high, stiff shanks and low, broad heels ordered. In certain cases it is necessary to prescribe a foot plate, usually one combining a metatarsal elevation, in order to distribute the body weight throughout the entire sole and relieve the heel and ball from excessive weight bearing. These plates should not be used until a considerable degree of calf relaxation has been accomplished and a pronounced metatarsal elevation should be avoided until the tendons of the toes are relaxed.

Depression of the Anterior or Metatarsal Arch.

Synonyms.

Anterior metatarsalgia; Morton's neuralgia; Weakened metatarsal arch; Burning soles.

Definition.

Anterior metatarsal arch depression is a deformity of the arch (so called) formed by the heads of the metatarsal bones, in which one or more of the bones are abnormally depressed upon weight bearing and do not regain their normal position when relieved from pressure; or in which their abnormal depression results in characteristic painful symptoms irrespective of their position while at rest.

Types.

Several types of anterior or metatarsal arch depression may be observed. First, those cases in which one or more of the metatarsal heads are displaced downward and remain in this position when the foot is relieved from pressure, the fore-foot being flexible and the arch capable of being replaced in its normal position. Little or no change in the soft tissues. Second, arch depression in which the metatarsal heads are more or less fixed in their depressed position, either by changes in and about their articulating surfaces or by contraction of the extensor tendons. Third, arch depression in which the rigidity is the result of inflammatory or osseous changes in and about the joints. Fourth, abnormal arch depression under weight bearing followed by a return to normal contour when the body weight is removed, with no evidence of deformity or metatarsal weakness. These are the relaxed fore-feet in which the paroxysms of pain and muscular cramp are designated as **Morton's Neuralgia or Morton's Toe.**

Etiology.

Metatarsal depression is a deformity of adult life found more often in women than men and especially in women of the nervous type. The majority of these cases may be traced to improper foot-gear. Tight, narrow, pointed shoes which constrict the fore-foot and restrict the normal rising and falling motion of the anterior arch are accountable for 90 per cent of these cases. The high heel generally accompanies such a shoe and by throwing the weight forward upon the restricted fore-foot adds to the deformity. Again, a short shoe may produce this condition by fixing the toes in dorsi-flexion.

In certain cases neuritis or the various forms of arthritis are causative factors, but more frequently a history of these diseases is given by the patient suffering from a rigid depression of the anterior arch.

Long continued standing with the weight thrown upon the ball of the foot is a common cause in men, consequently this deformity frequently complicates weak-foot. Depression of the anterior arch is

invariably found in acquired hollow foot and usually accompanies hallux valgus or chronic bunion. In the latter conditions less weight is borne by the abducted great toe and thus unusual strain is put upon the metatarsal arch in the last act of walking.

Mechanics.

The anterior or metatarsal arch exists as such only when free from weight bearing, when pressure is put upon the ball of the foot the heads of the metatarsals depress and the arch formation is obliterated. This rise and fall gives resiliency and elasticity to the foot in walking, acting as a "shock absorber."

Upon examining the contour of this arch we find that it rises abruptly from the head of the first metatarsal to the head of the second, which is its highest point, and then gradually declines to the head of the fifth. The heads of the metatarsals also describe a backward curve from the head of the second which is longest.

Normally the greatest pressure is distributed in the neighborhood of the head of the third bone, but in abnormal conditions the head of the fourth is most frequently found depressed. This is due to over-riding by the heads of the third and fifth when the fore-foot is constricted or the weight thrown upon the ball by a high heeled shoe. Any or all of the metatarsal heads may be depressed however., depending upon the pressure exerted, the gait and the type of foot.

As a result of leverage and the construction of the metatarso-phalangeal articulations the toes go into dorsi-flexion as the metatarsal heads are depressed, or to express it contra-wise the metatarsal heads are depressed as the toes dorsi-flex. In either case contraction and partial atrophy of the extensor tendons takes place as a rule. It is also probable that there is a stretching of the transverse pedis muscle and transverse metatarsal ligament.

Synonyms.

The term "metatarsalgia" is used indiscriminately to designate all depressions of the anterior, metatarsal arch, whereas if used at all, it should designate those cases in which the fore-foot is flexible, with but little depression of the metatarsal heads or other physical

changes, the outstanding symptoms being those of weakness with plantar pain upon pressure. In these painful cases where depression is evident it is doubtless due to reflex muscular contraction as the result of the irritation and pain produced by pressure upon the plantar nerves.

The outstanding symptoms of metatarsal depression are those of fore-foot weakness with plantar pain upon pressure. The ball of

Fig. 43F

Diathermia Treatment of the Ankle by Means of Rubber Sponge Pads Covered with Flexible Mesh and Held in Position by Adjustable Wooden Clamps. These Electrodes Are Frequently Indicated in Treatments over Bony or Prominent Parts. Sprains, Synovitis, Arthritis or Fibrous Ankylosis of the Ankle Joint May Be Treated in This Manner.

the foot is extremely sensitive to uneven surfaces, while long standing cause the soles to burn and pain. Callus exists at the point of greatest pressure. Pains of the outer dorsal surface as well as leg and knee pain is common. Fatigue is marked. In rigid depression of the anterior arch the gait is awkward with little buoyancy as the

patient hastens to remove his weight from the painful ball of the foot. This pain is due to distinct pressure upon the tender joints, as well as the lateral constriction caused by the shoe. Palpitation elicits pain upon pressure or lateral constriction, with prominence of one or more of the metatarsal heads in the obliterated arch. In many cases it is impossible to restore the bones to their normal arched contour. These are the cases in which there is marked dorsi-flexion of the toes and compensatory tendon shortening.

In certain cases a series of typical symptoms constitute what is known as *Morton's Neuralgia.* These symptoms are produced by the heads of the third and fifth metatarsals over-riding the head of the fourth and pinching the digital branch of the plantar nerve between them. The attack begins with a feeling of discomfort and numbness in and about the fourth metatarsal head, followed by a burning, tingling sensation which soon develops into a lancinating pain that radiates to the toe, dorsum of the foot and even up the leg. The pain is immediately followed by a characteristic cramp, which is only relieved by removing the shoe and manipulating the arch and affected toe. Slight swelling and soreness may exist for a few hours following an attack. In some cases the patient experiences a distinct "click" as the head of the fourth metatarsal slips downward. While this condition is usually localized about the fourth toe, any or all of the metatarsal heads may be affected. Morton's neuralgia is almost invariably found in individuals of the nervous type and the attacks come on only while the shoe is worn.

Treatment.

The pain and sensitiveness found in those relaxed metatarsal arch depressions known as metatarsalgia is best treated by heat and radiant light. Very frequently the heat produced by the high frequency current with a non-vacuum condenser electrode will be sufficient to dispel the pain and sensitiveness. Again it may be necessary to expose the fore-foot to radiant light for 10 minutes. If these methods fail to relieve the pain and relax the tissues recourse must be had to direct diathermia, in which the electrodes

are placed so that the heat will traverse the tissues surrounding the metatarsal heads. This should be followed by sedative massage or vibration and the support of the arch by a felt plantar pad placed just back of the metatarsal heads and held in place by a circular adhesive plaster strapping.

While Morton's neuralgia is seldom seen during the paroxysm yet there is no doubt that it could be cut short by a diathermic treatment if applied at that time. As a routine treatment diathermia, visible light or the high frequency current is indicated in these cases, followed by positive galvanism. Certain cases appear to be benefited, and the seizures preventd, by frequent applications of the rapid or interrupted sinusoidal currents. Hot foot baths (100° to 104° F.) followed by a brief cold douche or spray are frequently of decided benefit in these cases. Stimulative vibration or massage are contra-indicated in Morton's neuralgia. Many of these cases require the constrictive support afforded by a circular strapping or bandaging of the fore-foot rather than the elevation produced by a plantar pad.

Those cases of anterior arch depression exhibiting rigidity due to fibrous changes about the joints and shortening of the extensor tendons indicate heat in the form of diathermia or visible light from 20 to 30 minutes, followed by deep vibration and manipulation of the anterior arch and forced plantar flexion of the toes. This treatment should be followed by raising the arch with a metatarsal pad held in place by a circular strapping. Exercises should be directed and their importance stressed.

In all cases of metatarsal depression in which contraction of the calf muscles exists it will be necessary to treat this condition as well. Again, metatarsal deformity frequently accompanies weakfoot and must be treated in conjunction with it.

Depression of this arch following, or associated with, plantar neuritis or arthritic infection should be treated by diathermia, visible light, super-heated air or hot foot baths. Stimulative vibration, massage or manipulation is contra-indicated.

Diseases, Injuries and Deformities of Joints

Synovitis.

Definition.

Inflammation affecting the synovial membrane alone is called synovitis. However, this seldom occurs, for in the majority of cases it is associated with inflammation of the joint, overlying tendons or periarticular connective tissue. It may be acute, subacute or chronic.

Etiology.

Traumatism is the cause of the majority of cases of true synovitis. Other causes are gonorrhoea, rhematism, specific fevers, gout, syphilis and tuberculosis. Loose bodies in the joints associated with synovitis may be due to injury but more often are the result of a tubercular process.

Pathology.

As in acute inflammation elsewhere, there is hyperemia and exudation first into the synovial membrane and then into the joint, so that it becomes distended with fluid which consists of plasma and leucocytes and some synovial fluid. The lymph which may become deposited from the plasma is either absorbed or organized to form adhesions.

Symptoms.

Acute Synovitis. The joint becomes hot, distended and painful, due to the inflammatory process as well as the out-pouring of synovial fluid within the joint, causing pressure. The joint is held in the position of partial flexion which permits of the greatest ease. The muscles which move the joint rapidly waste from some reflex disturbance and the joint usually remains weak for some time after the acute stage subsides from softening of the ligaments. If infection accompanies traumatism the inflammatory symptoms extend to the other structures in and about the joint and there is a general arthritis. Adhesions may render the joint stiff and painful.

Chronic Synovitis. This may follow an acute attack or be chronic from the first. In the latter case there may be a sprain, a loose body or an injury of the inter-articular cartilage. Chronic

synovitis is accompanied either by a marked effusion into the joint *(hydrops articuli or hydrarthrosis)* or hypertrophy of the synovial membrane.

Movements, especially of extension, are limited and grating or cracking remains as evidence of roughened membrane.

Treatment.

Acute traumatic synovitis should be treated by diathermia as soon as possible after the injury. (As the ankle joint is the one most frequently injured we will use it as an illustration.) The foot should be placed in about one-half inch of saline solution which acts as one electrode, while a cuff electrode encircles the leg at about its middle. About 500 milliamperes of current is the usual dose tolerated and it should be maintained from 40 to 60 minutes. Follow this with a sedative massage, making no manipulative movements, and the application of a Gibney or Cottrell strapping. Repeat this treatment daily for a week. If carefully carried out this method will secure satisfactory results and prevent later fibrosis. When the diathermia current is not accessible the use of radiant light and heat is the next best modality to use. Its application should continue for one half hour, being repeated daily to the point of toleration and followed by massage and strapping. Where neither diathermia nor visible light is to be had the foot should be immersed in a hot foot bath (100° to 104° F.) for one-half hour. Follow this by a cold spray or doüche for 5 seconds and then massage the part gently for 15 minutes before applying an ankle strapping. The Tesla or Oudin current may be used indirectly by holding the glass bulb of the condenser electrode in one hand while massaging the joint with the other. (Fig. 38A.) This is an effective method of securing the benefit of both massage and the high frequency current.

Acute infectious synovitis may be treated as previously indicated providing pus does not exist. Heat in any form is contraindicated until the pus cavity is open and draining.

Chronic traumatic synovitis is to be treated by diathermia, preferably by the application of plate electrodes so placed as to secure a

through-and-through application of the joint. This is especially important since cases of traumatic synovitis are neglected cases usually exhibiting fibrositic changes and lessened joint motion. This should be followed by stimulative massage, vibration and manipulation in an effort to secure free and painless joint motion

Fig. 43G

Showing Method of Treating Affections of the Great Toe Joint by Diathermia. The Foot Is Tilted by Inclined Foot-Plate with the Joint Resting in the Saline Water-Bath. One Terminal Is Clipped to a Strip of Block-Tin Placed in the Water Near the Joint. The Other Electrode Being Attached to a Cuff Electrode About the Calf. If Desired, This Latter Electrode May Be Replaced by a Flexible Metal Mesh Electrode Applied to the Outer Border of the Dorsum of the Foot. Inflammatory Conditions of the First Metatarso-Phalangeal Joint, as Well as the Fibrosis of Chronic Bunion, Hallux Valgus and Hallux Rigidus Are Best Treated in This Manner.

to the normal limit. Visible light may be used where diathermia is not available or applications of super-heated air are indicated for 40-minute periods. The presence of fibrous adhesions frequently demand negative galvanism for its softening effect, while

the slow sinusoidal current is used to tone up the wasted muscles resulting from disuse.

Chronic infectious synovitis means that the primary inflammatory process has invaded the general joint structure and its treatment must be surgical if pus exists, and if not it must be directed to the existing condition, generally an arthritis.

Sprain of Ankle Joint.

The ankle, from its position and structure, is especially liable to injury, the foot being turned inward through an unguarded movement. The injury may extend to the synovial membrane, may rupture ligaments or muscles or strain tendons and tendon sheaths. If the foot turns inward the outer side of the ankle and foot is most injured and vice versa. The clinical picture presented by sprains is that of ecchymosis, pain and functional weakness, and later, inflammation, peri-articular oedema and stiffness of the joint. The sanguineous effusions act as an irritant, preventing the reunion of the tissues.

Treatment.

Ordinarily the indications for the treatment of sprain are the same as described under traumatic synovitis, which is in fact in most cases due to a sprain. Treatment is directed to the relief of pain and swelling by encouraging the absorption of lymph exudate and the prevention of later fibrosis and muscle fixation. Heat, massage and flexible strapping are the essential points in the treatment. The application of immobilizing dressings, as plaster casts, and long periods of rest and joint inactivity is not good practice and long since discarded in the treatment of sprains.

Arthritis.

Definition.

Arthritis is an inflammation involving all the structures of a joint, i. e., bone, cartilage, ligaments and synovial membrane. The inflammation may begin in any of these structures, but sooner or later all are involved. Inflammation of the synovial membrane may be an exception to this rule, in that a synovitis may or may not

involve other joint structures, if it does take place we have an arthritis.

Etiology.

Arthritis is the result of traumatism or an infective organism. A sprain is the most common form of traumatic arthritis, the injury to the joint being sufficient to not only produce an inflammation of the synovial membrane (synovitis) but all the other joint structures as well. Thus it will be seen that the general term "sprain" may be applied to the inflammatory process produced by traumatism in various structures of the joint and that the severity of the sprain is dependent upon the extent of the process.

Toxic arthritis is a secondary lesion. The primary foci may be in any tissue of the body, most frequently, however, in the teeth, tonsils, middle ear, accessory sinuses, gall bladder, appendix, colon or prostrate gland; in which case the infection is known as "focal." In addition to these causes various constitutional diseases as tuberculosis, gonorrhoea, syphilis, gout and rheumatism affect the joints. Certain infectious diseases as measles, scarlet fever, typhoid fever, erysipelas, etc., may also cause an inflammation of joint structure.

Pathology.

The pathology of an acute traumatic arthritis is that of an acute synovitis in which the process is extended to nearby tissues. In an acute septic arthritis the synovial membrane becomes hyperemic and pours out synovial fluid and pus, the cartilage becomes inflammed, softened and ulcerated, and its place taken by granulation tissue. The underlying bone becomes inflammed and carious and at the articular margins osteophytes are formed. The ligaments are softened and permit displacement, while the muscles rapidly atrophy. The treatment of these acute septic cases requires immediate surgical interference. The joint must be freely opened, washed out and drained. Toxaemic symptoms are pronounced and the prognosis is grave.

Arthritis due to focal infection usually begins in the tissues surrounding the joint with extension to the synovial membrane, followed by erosion and destruction of the articular surfaces and

the formation of fibrous adhesions. Tubercular arthritis is particularly liable to the destruction of the articulating surfaces of the bones.

Symptoms.

The symptoms are both local and general. The former are those of inflammation: pain, heat, redness, swelling and loss of function. Acute septic cases run a rapid course with all local symptoms accentuated and evidences of rapid destruction of joint structure. The general symptoms are those of a general sepsis as a result of the absorption of bacteria and their toxins.

The symptoms of arthritis due to focal infection depend upon the character and intensity of the infection; the early cardinal symptoms being pain, limitation of motion and swelling of the structures around the joints. These occur in rapid succession. One or more joints may be involved.

Special Forms of Arthritis.

Tubercular Arthritis.

The great proportion of chronic joint diseases are tubercular in origin, the tubercle bacilli being carried by the blood and deposited in any part of the joint structure. The minute foci of infection coalesce and granulation tissue replaces normal structure. The disease may be confined to the interior of the bone or it may force its way into the joint cavity destroying the cartilage and finally the articulating surfaces of the bones. A tubercular fluid accumulates forming an abscess, the pus of which finds exit from the joint capsule into the surrounding tissues, through which it is discharged. Abscess is more common in tuberculous disease of the ankle joint than other joints. The contour of the joint is changed, becoming globular or spindle shaped and the skin is white and thickened.

Tubercular arthritis of the ankle joint is less common than that of the knee or hip. In the ankle and foot it is most frequently located in the astragalus, next in frequency in the os calcis, and then in the following order: Lower end of the fibula, scaphoid,

cuboid, first metatarsal, cuneiforms and lastly the other metatarsals.

The symptoms of tubercular arthritis in the ankle or foot are usually subacute in character and frequently mistaken for sprain or rheumatism. Pain is, as a rule, but slight in the earlier stages but when the bones are involved it is severe, without acute, inflammatory symptoms. The ankle is sensitive, there is a limp, discomfort and pain after over-use or at night. The patient walks upon the heel and inner border of the foot, with the leg rotated outward. Deformity is a constant symptom, being due to the change in foot posture, the destruction of joint tissue and contraction of muscles as the result of reflex action. At first the deformity is that of valgus, later the heel is raised resulting in an equino-valgus and later when the foot is incapable of weight bearing it hangs in a position of equinus. Where the astragalus is the site of primary infection the range of adduction and abduction is lessened. When confined to the astragalo-scaphoid articulation the foot is fixed in extreme abduction and may be mistaken for rigid weak-foot.

Arthritis Deformans; Osteo-arthritis; Rheumatoid Arthritis.

Under these headings are included a number of degenerative affections of joints whose origin is obscure. Little is known as to the etiology of these diseases. Exposure to cold and damp may have some influence. A bacterial origin is suggested and also that they are of toxic origin, the result of focal infection. In many cases no source of infection can be found; in others, the disease persists after apparent sources of infection have been removed, proving that the cause differs in different individuals.

Clinically two types of these conditions are recognized i. e., *hypertrophic* and *atrophic*. The former is found more frequently in old people and may be limited to a single joint. Primarily there is a softening of the cartilage which becomes worn away at the points of greatest pressure and thickened around the edge of the articulating surface. Later on this cartilage becomes partially ossified and new bone is formed underneath. Meanwhile the exposed bone upon the articulating surfaces becomes hard, dense and worn away

and the bony enlargement combined with destruction of the bearing surface produces the characteristic deformity. The position and shape of the bones in the joint are changed. The synovial membrane becomes hypertrophied and the synovial fluid decreased in amount. Ligaments and tendons are weakened and adherent to the other tissues and the muscles atrophy and accommodate themselves to the deformity. Motion is limited in and about the joint. Symptoms come on slowly and consist of pain, difficulty in moving the joint, increasing enlargement, distortion of the part and restricted motion.

Atrophic arthritis is more acute, general and progressive than hypertrophic. It is a disease of childhood and early adult life and resembles chronic rheumatism. The joints are enlarged but the disease is of the soft parts, the articulating bony surfaces are only secondarily involved. There is no new formation of bone or cartilage but rather an atrophy of joint tissues as well as tissue of the limb. The final result is either ankylosis or limited motion accompanied by flexion deformity, with general muscular atrophy.

Local Arthritis Deformans.

This name is given to a traumatic arthritis in which the deformity is localized in the first, or first and second metatarso-phalangeal joint. It is usually found in older patients and limited to the joint of one foot. In certain cases the symptoms arise gradually without apparent cause and increase in intensity as the deformity progresses, but in the majority of cases a definite history of injury may be obtained. This may result from an ill fitting shoe making pressure over the great toe joint; direct violence produced by a weight falling upon the joint; its being stepped upon; or a stubbing of the toe. Such cases are no doubt of traumatic origin, while the former cases, of slow onset and uncertain history, are possibly rheumatoid in character.

The symptoms of this condition have to do with pain and restricted motion in the first metatarso-phalangeal joint. In some cases the foot is normal in appearance and the restricted motion very slight, again the joint is large and the motion greatly lessened

in one or more directions. In either case the pain is localized in the joint and usually is apparent after long standing, walking, or any cause which forces the toe into dorsi-flexion. It may be neuralgic in character and referred to the end of the toe.

The pathology of these conditions is that of a hypertrophic arthritis in which the over-growth of bone takes place in the head of the first metatarsal and the base of the first phalanx, the former being usually more involved. This hypertrophy may be upon the dorsal, plantar or lateral surfaces of the bone, the dorsal surface being the most common site, while over-growth upon the plantar surface is uncommon. Due to dorsal over-growth normal extension is impossible and as the weight is carried upon the great toe in the last act of walking the strain put upon the rigid or semi-rigid joint results in continued irritation which encourages an increased formation of bony tissue. Where the bony over-growth exists upon the lateral as well as the dorsal surface of the joint a similar condition will usually be found upon the inner side of the second metatarsal as a result of pressure from the first. As deformity continues the inflammatory symptoms of arthritis become more pronounced with muscular spasm due to the constant irritation.

Gonorrhoeal arthritis is due to the gonococcus being deposited within the joint by the blood stream. The ankle, knee and wrist are especially susceptible to this infection which is nearly always very acute, beginning as an acute synovitis and extending to the periarticular structures. This is a form of septic arthritis and nearly always accompanied by general symptoms, as a high temperature and a chill. Suppuration is uncommon. The disease resists treatment and ankylosis is a common sequela.

Neuropathic Arthritis. This is a peculiar condition seen in patients with locomotor ataxia. It may occur as a simple synovitis or as a destructive osteo-arthritis, the latter being known as Charcot's disease. In the latter type the cartilage degenerates and with it the underlying bone is worn away by the movements of the joint. A new formation of bone and cartilage takes place with hypertrophy of the synovial membrane and increase of the joint

fluid, resulting in a general enlargement of the joint. Finally the joint becomes weakened, the limb atrophied and incapable of supporting the body.

Treatment of Arthritis.

The various types of arthritis furnish a fertile field for the application of physical measures, and the results will be gratifying

Fig. 43H

In Treating Conditions About the Heel by Diathermia the Foot May Be So Inclined by the Use of a Wooden Foot-Plate That Only the Heel Rests in the Foot-Bath, While a Block-Tin Plate Electrode Is Strapped upon the Posterior Surface of the Leg. In This Way Conversive Heat Is Localized in the Heel and Lower Posterior Surface of the Leg. Note Position of Terminal Clips. Treatment of Calcaneo-Bursitis, Achillo-Bursitis, Strain of Tendo-Achilles, Tendo-Synovitis, Chronic Frostbite of the Heel, etc., May Be Accomplished by This Method.

although not spectacular. In the infectious forms the source of infection must be sought and eliminated if possible. This is often a difficult matter. The x-ray must be used to confirm the diagnosis in practically every case. The fact that joint symptoms are often

temporarily exacerbated after the focal areas are cleared up must not be overlooked. Again, the pain and inflammation in arthritis is frequently increased during the first few physio-therapeutic treatments. Do not use diathermia, visible light or any form of heat upon a joint in which pus is confined or in a tubercular joint in which the joint structure has started to break down. After free drainage has been obtained heat may be used to advantage.

The treatment of *traumatic* arthritis consists in the application of direct diathermia, visible light, super-heated air, high frequency electricity, hydrotherapy and massage. Of these modalities diathermia is the best method of securing deep, active hyperemia. In the larger joints of the foot and leg the electrodes should be so applied that the heat is produced directly through the joint. In the smaller joints where it is difficult to adjust electrodes, the water bath may take the place of one electrode. Visible light may be used to its full intensity over the injured joint for 15 to 30 minutes. It is well to localize the treatment by covering surrounding parts with a towel. Local heat may also be produced by the high frequency non-vacuum condenser electrode. This is especially useful about the joints of the toes and metatarsus. Vaso-motor stimulation by plunging the foot alternately into hot and cold water is useful. All treatments should be followed by prolonged, gentle massage employing friction and effleurage carried well above the injured joint. After the necessary physical treatment is given the joint should be supported by strapping or bandaging and actively used. Do not immobilize or put the joint completely at rest, allow it to function within reason.

In chronic traumatic arthritis the treatment is directed toward the softening and breaking up of fibrosis. Diathermia, or superheated air, vibration and forcible manipulation are indicated in the order given.

Tubercular arthritis is best treated by long applications of visible light, or diathermia may be used early in the process before suppuration has occurred. Its application is best secured by the cuff and water bath method. General ultra-violet irradiation may be

given to the point of producing tanning and continued over long periods by gradually increasing and decreasing the length of exposure. In those cases in which the process is localized and superficial the water-cooled mercury vapor lamp may be used in contact All tubercular joints should be protected against injury by protective dressings.

Rheumatoid Arthritis. Arthritis Deformans. A search for the focus of infection and the correction of the patients diet, habits, etc., is essential. Heat is indicated in some form, diathermia, radiant light, super-heated air or hot baths may be used. Of these diathermia combined with radiant light is the most satisfactory. As a rule it is desirable to secure through-and-through heating rather than the more superficial heating accomplished by the cuff method. Massage, consisting of friction and effleurage, should be used, followed by vibration and manipulation in every case. Mechanical vibration plays an important part in the treatment of this disease for the relief of muscular tension, overcoming the stiffened joints and improving local metabolism and elimination. When preceded by diathermia or visible light results are increased and expedited. Manipulation should follow vibration and consist in an effort to put the joints through their normal range of motion.

The use of the galvanic current is frequently more sedative than diathermia, and again, it is used for its chemical action. The galvanic current is capable of causing decomposition of any compound through which it is passed and in this particular instance it is the decomposition or reduction of worn out animal tissue into its final components that is desired. The galvanic electrodes, of equal size, should be applied in such a manner that painful and swollen joint lies between them and that the current traverses the affected area. The current should be as strong as the patient will tolerate and continue for 30 to 40 minutes, repeated daily. The theory of this procedure is that it will cause an electrolysis of the local tissues. Debris is easier broken down than normal cell structure. When the pain does not yield the positive pole is made smaller and placed

over the site of the pain for its sedative effect following the interpolar action.

Local Arthritis Deformans is treated as just described by diathermia, vibration and manipulation. The diathermia application is best secured by tilting and inclining the foot so that the joint rests in about one-half inch of saline solution, the opposite electrode, of block tin or flexible mesh, being placed upon the outer side of the dorsum of the foot. (See Fig. 43G.) Frequently the application of negative galvanism, for its softening action, or the interrupted rapid sinusoidal current are used to follow diathermia, especially in those types in which peri-articular symptoms are outstanding. In applying vibration the joint should be held in dorsiflexion, with the vibratory stroke short and rapid at first, and later slow and deep.

Gonorrhoeal Arthritis. This is an infectious arthritis, running a very acute course, followed by a sub-acute or chronic course. Prolonged visible light treatments are indicated in the acute, painful, inflammatory cases. In sub-acute cases diathermia; chronic cases diathermia with massage, vibration and manipulation.

Ankylosis.

This term is used to designate the fixation of a joint in an attitude of deformity by tissue change, either within or without the joint. Ankylosis may be due to: 1. Union between articular surfaces. (It may be fibrous or bony. Fibrous union follows erosion of the cartilages and some movement is possible. Bony union occurs after complete destruction of the articular cartilage and no movement is possible.) 2. Partial or complete obliteration of the synovial cavity by adhesions. 3. Contraction or shortening of the muscles, tendons, ligaments or peri-articular structures. 4. The presence of osteophytes or loose bodies within the joint.

Treatment.

Osseous ankylosis is uninfluenced by any physio-therapeutic modality and recourse must be had to surgery. In the treatment of fibrous ankylosis heat is the first agent to be used for the relaxation and disorganizing of the tissues, making their subsequent

manipulation and stretching easier and less painful. Heat also dilates the blood and lymph vessels and thus carries off the traumatic exudate after the treatment as well as increasing the general nutrition of the part. Diathermia is by far the best method, radiant light, super-heated dry air, or hot foot baths are of value in the order named.

Ordinarily direct diathermia through the fibrosed joint is the proper procedure. This may be secured by block tin electrode or rubber sponge pads covered with flexible mesh, applied upon opposite surfaces of the joint. The relative size of the electrodes governs the localization of heat, as has been previously described under diathermia technic. "Cross firing" of the joint or changing the general direction of the electrical current may be secured by reversing the attachment of the terminal clips upon the electrodes several times during the course of the treatment. The sedative diathermia technic is used from 30 minutes to one hour, dosage to the point of patient's toleration.

Upon the foot it is frequently difficult to obtain satisfactory application of block tin electrodes, in which case the salt water foot bath may be used as one electrode and a block tin plate or piece of flexible mesh as the other; or a cuff placed above the ankle, or about the calf, may be used in combination with the foot bath. Where radiant light is used the exposure should be intense and from 30 minutes to one hour in duration, the light being shifted from the joint when the heat becomes too great and then quickly brought back again. Hot air baking may be used for at least one hour, while hot foot baths (100° to 104° F.) should be continued 20 minutes for their relaxing effect. Frequently a short, hot foot bath for 5 minutes followed by a momentary cold spray or douche is used after manipulation to remove the strain following this procedure.

After the joint is thoroughly heated through it should be put upon the stretch in the *direction of restricted motion* and deep, long stroke vibration or percussion applied for several minutes. Following this powerful manipulation is applied, using all the force that

the patient will stand. An attempt should be made to put the joint through all its normal motions, especially those in which motion is most restricted. Active motion and exercises should be directed.

Negative galvanism is frequently used after diathermy in order to obtain an additional softening of the fibrous adhesions. The negative electrode, which should be the smaller, is placed over the seat of adhesions and the indifferent electrode upon the opposite surface of the foot or ankle. The current should be used to the point of toleration from 15 to 30 minutes. Ionization may be secured by saturating the negative pole with a solution of sodium chloride or potassium iodide.

Treatments directed to the relief of fibrous ankylosis should be frequently repeated, daily if possible, but at least twice a week. The joint may be supported by bandaging or adhesive plaster strapping, but it should not be immobilized or put completely at rest.

Hallux Valgus is a deformity in which the great toe is turned outward, abducted, while the first metatarsal bone is adducted or turned inward, thus causing a partial luxation in which only the outer condyle of the first phalanx is in contact with the head of the metatarsal. The projecting inner condyle of the head of the first metatarsal bone makes the prominent or enlarged joint, over which a bursa often forms as well as a corn or callus. The combination of joint and bursal enlargement with callus formation constitutes the so-called "bunion." The deformity of hallux valgus consequently consists of an abducted great toe, a widened forefoot and frequently a depression of the anterior arch as a result of a change in weight bearing.

Etiology.

Short, tight, pointed or high-heeled shoes are the most common causes of acquired hallux valgus. Injury, as stubbing the toes, especially in childhood, is an occasional cause, while the various diseases attacking the joints as gout, rheumatism or arthritis may produce this deformity, either directly or indirectly. Deformities of the arches of the foot may also be a cause. In a few cases hallux valgus is hereditary.

Pathology.

The outward displacement of the toe uncovers the inner condyle of the metatarsal head and here the cartilage atrophies and degenerates while the exposed bone roughens and becomes irregular, with possibly the formation of exostoses about the condyle, thus aggravating the enlargement and lateral pressure. The outer surface of the metatarsal head atrophies and absorbs. Soft tissues upon the outer surface shorten, the flexor tendon with the sesamoid bone being carried outward; the tissues upon the inner surface of the joint lengthen, while the extensor tendon is usually shortened.

Treatment.

The treatment of hallux valgus consists in an effort to relax the contracted tendons and soft tissues and to prevent the formation of bony overgrowth. Where the latter condition has extended to the point of bony ankylosis physio-therapy is without avail. Diathermia or visible light are used to relax the contracted soft tissues as well as to secure an active joint hyperemia. This is followed by vibration of the joint while it is held in a position of adduction and plantar flexion, and lastly a series of short, jerky manipulations applied in the same direction. As metatarsal depression generally accompanies hallux valgus it must also be treated as previously outlined. In all cases the broadened fore-foot should be narrowed by a circular strapping of the foot. The wearing of a night splint will do much to encourage the toe to resume its normal position in early cases if proper shoes are worn during the day time. The treatment of the painful inflammatory symptoms attending hallux vagus will be discussed under the subject of bursitis.

Hallux Rigidus.

Synonyms. Hallux flexus; painful great toe.

Etiology.

This condition frequently accompanies weak-foot and is generally found in young people. In many cases a history of traumatism may be obtained, such as stubbing the toe, kicking a hard object or the toe being bruised or stepped upon.

Symptoms.

The cardinal symptoms are pain in and about the great toe joint and restricted dorsal flexion. The pain is burning or throbbing, increased in character by long continued standing or walking and usually accompanied by redness and congestion of the enlarged and thickened joint. Attempts to dorsi-flex the toe result in acute pain and muscular resistance. Restriction of motion in cases of long standing is complete, the first phalanx being frequently plantar flexed. In early cases the joint may present no deformity with but slight limitation of dorsi-flexion and yet an effort to secure further dorsi-flexion causes acute pain and muscular spasm.

Pathology.

This condition is primarily one affecting the soft tissues of the joint, probably a peri-arthritis. As it continues the soft tissues thicken and the ligaments and tendons lengthen or shorten according to their location about the joint. Restriction of motion is probably due to this change combined with a decided muscular spasm. Chronic cases may exhibit changes in the joint structure, due to pressure and disuse.

Treatment.

Direct diathermia is the indicated treatment. This is best accomplished by tilting and inclining the foot so that the great toe joint rests in one-half an inch of water in which one terminal is placed near the affected joint. The other electrode should be placed upon the outer surface of the dorsum of the foot. (See Fig. 43G.) The treatment should continue for half-an-hour and be repeated at frequent intervals. Massage, vibration or manipulation should not be attempted until the sensitiveness and muscular resistance is lessened, when gentle vibration and massage should be instituted. A half-moon, skived felt pad, of one-half inch felt, should be placed upon the sole of the foot, encircling and just back of the head of the first metatarsal bone. This should be held in place by circular straps which are brought well forward over the first metatarsophalangeal articulation. Positive galvanism is useful at times in relieving the extreme sensitiveness of these joints.

Hallux Flexus or Hammer Toe is a contraction of one of the toes, usually the second, in which the first phalanx is dorsi-flexed the second plantar flexed, while the third may be flexed or distended. The contracted toe is over-lapped by its fellows and its prominent dorsal surface is pressed upon by the shoe, producing corns, callus or adventitious bursae. Hammer toe may be acquired or congenital and is usually found upon both feet. As a result of long continued deformity all the soft tissues about the joints are changed, especially the capsular ligament and the lateral ligaments of the first inter-phalangeal joints which are shortened.

Treatment.

Chronic cases indicate surgical treatment. Hammer toe in young children may be corrected by vibration and manipulative movements tending to straighten and stretch the toe. A ball vibrator applicator should be used, pushing it up under the flexed toe and pulling upon the end of the toe with the fingers of the other hand while the vibrator is delivering a rapid, short stroke. Applications should continue for five minutes. The toe should be manipulated daily by the nurse or mother and held in proper position by narrow strips of adhesive plaster passed over and under it and fastened to the adjoining toes.

Dancer's Toe. Injury to Sesamoid Bones.

Pain and tenderness under the head of the first metatarsal bone increased by dorsi-flexing the great toe is generally due to injury or over-use of this part of the foot, as found in dancers or acrobats. The conditions may be due to a fracture of a sesamoid bone, but more frequently to a temporary dislocation with inflammation of the tendon sheath and surrounding tissues.

Treatment.

Direct diathermia through the painful area and the application of a felt pad which will relieve that part of the fore-foot from pressure. An x-ray may be necessary to clear up the diagnosis.

Diseases and Injuries of Nerves.

In order to comprehend the subject of muscle nerve testing it is necessary to consider the minute anatomy and physiology of ner-

vous tissue. The *nerve cell* is that portion from which nervous impulses arise. The *nerve fibre* or *axis cylinder* is a prolongation of the nerve cell, ending in the *end brush* or *end organ*. A group of nerve fibres bound together by dense connective tissue, with blood vessels and lymphatics which supply them with nutrition, and surrounded by a connective tissue envelope is known as a nerve trunk or "nerve."

By the term *neuron* we include the entire structure, consisting of the nerve cell, nerve fibre and end organ. The *central motor neuron* begins with the motor ganglion cell in the cortical motor area of the cerebrum. The nerve fibre passes downward and crosses over to the opposite side of the body and terminates in the *end brush*, which is situated at its particular level in the spinal cord. (In the case of nerve fibres supplying the leg and foot the end brush would be located in the sacral plexus, which is formed by the fourth and fifth lumbar and the fourth upper sacral nerves).

The function of the central neuron is to convey the impulse from the brain along the nerve fibre to the end brush, where it is translated into an energy which is taken up by a large multipolar cell in the gray matter of the anterior horn of the spinal cord.

The *peripheral neuron* consists of this latter cell and its prolongation or nerve fibre and its termination or end organ, which is found in the particular muscle fibre which the nerve controls.

The function of the peripheral neuron is to carry into execution the message sent from the central neuron in the brain. It acts as a sort of relay. The motor cell of the central as well as the peripheral neuron, besides generating impulses, presides over the nutrition of all the parts of which they are formed and the organs to which their branches are distributed.

In cerebral apoplexy we may have pressure produced by the blood clot over the nerve cells lying in the motor cortical zone. Such a lesion would interfere with the generation of motor impulses. No impulses, or messages, arriving at the end brush none could be picked up by the peripheral neuron and the muscle supplied by this particular neuron, or nerve, would be without instruc-

tions and cease to function, therefore paralyzed. Owing to the fact that the peripheral motor cell controls the nutrition of the muscle to which its branches are distributed, this cell being intact, the nutrition of the muscle would not suffer and there would be no atrophy, excepting that which results from non-use.

When a lesion occurs in the *peripheral* neuron conduction from the cell to the end organ is interfered with, the trophic or nutritional center is cut off from the nerve and muscle and there is a flaccid paralysis with early and rapid atrophy. Upon testing such a nerve electrically the axis cylinder fails to conduct the artificial stimulus because the nerve has *degenerated* from lack of nutrition, there is no muscular contraction, hence we have the phenomenon of **reaction of degeneration.** In reality, it is the *failure to react* to electrical stimulation that denotes the fact that the nerve fibre has degenerated.

Every lesion in the peripheral motor neuron can be located by the electric test, but lesions in the central motor neuron can only be inferred by eliminating peripheral involvement.

Every healthy nerve responds to stimulation, whether it be physiological or artificial. In the case of a motor nerve there is always a muscular contraction; in a sensory nerve sensation of some kind is carried toward the center. When a nerve and muscle are normal the response to electric stimulation is a quick, lightning-like contraction. If, however, the nerve or muscle is diseased or injured the contraction is slow, gradual and worm-like, if not entirely absent.

Muscle Nerve Testing.

Normal muscle responds to the faradic and rapid sinusoidal currents by going into tonic contraction, because the interruptions or alternations are so rapid that it cannot respond to each electric impulse. With the galvanic current a muscular contraction occurs only at the moment of closing and breaking the circuit. During the interim, while the current is flowing, chemical changes occur in the tissues but muscular contraction is not in evidence.

The galvanic current travels from the positive to the negative

pole. When the positive pole is placed upon the central end of a motor nerve i. e., the end nearest the brain, and the negative pole upon the peripheral end of the same nerve the electric current flows in the same direction as the normal "nerve current". In other words the electric current flows with the nerve current, as a chip floats down stream. This is called a *descending* current. If the position of the electrodes are reversed the electrical current will flow from periphery to center, or against the nerve current. This

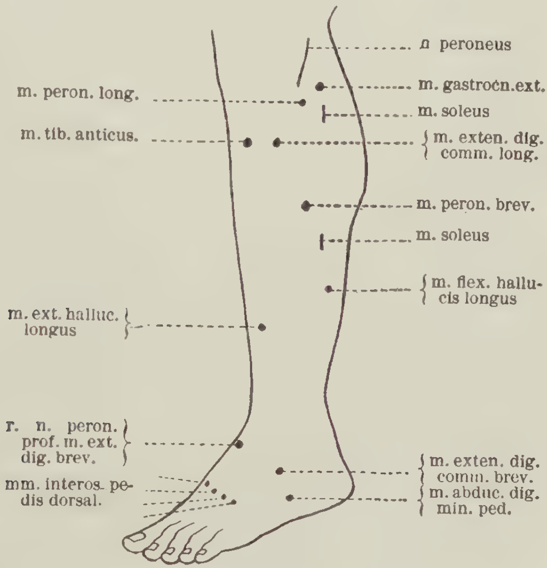

Fig. 44
Motor Points upon Outer Side of Leg.
Muscles (m), Nerves (n).

is known as an *ascending* current and it will require a stronger current to produce a contraction by this method than by the former, for the reason that the electrical current is flowing *against* the nerve current and is antagonized by it.

When the anode is placed over the origin of a *normal* nerve, or over its **motor point,** (Figures 44, 45, 46) it requires but a very small amount of current to produce a muscular contraction at the moment of closing, or switching on the current. Such a contraction is known as the *cathodal closure contraction,* abbreviated C. C. C. If the current is opened or broken no contraction occurs.

When the anode is placed at the periphery or over the motor point of a nerve and the cathode over the spinal origin of the same nerve a contraction may be secured at the closing of the current. This is known as the *anodal closure contraction*—A. C. C. As it is an ascending current nearly twice the volume of electricity required to produce the C. C.C. will be necessary.

Muscular contractions may also be secured by suddenly opening or breaking the circuit. If the anode is placed at the peripheral end of a motor nerve and the current turned on gradually no contraction will occur. If the current is now gradually increased in strength to nearly three times the amount required to produce the original C. C. C., then upon opening the current suddenly a similar contraction occurs. This known as the *anodal opening contraction*—A. O. C.

There is a fourth muscular contraction known as the *cathodal opening contraction*—C. O. C., but this is of little value as the strength of current required to produce it is very likely to be painful.

In muscle testing the inactive, or indifferent, pole consisting of a large, well moistened felt or gauze electrode should be placed over the spinal origin of the nerve. In the case of the leg and foot this would be over the sacral plexus; or it may be placed over the popliteal nerve just back of the knee. The active, or examining electrode, about the size of a ten cent piece, well moistened, is placed over the point of the muscle to be tested. Ordinarily this testing electrode is attached to an interrupting handle (Figure 48) by means of which the operator closes and opens the circuit. This may be used in all cases in which muscle reaction is more or less evident but in those cases in which only a very faint response is obtained the examining electrode should be fastened in place and not held by the operator. The slightest contraction must be noticed and the amount of current required to produce it. The degree of muscular reaction will determine the extent of nerve degeneration.

In muscle testing the faradic current should be tried first. If

this is not obtainable the rapid sinusoidal may be used. If no response is obtained the galvanic current should be used, both ascending and descending, closing and opening. The muscles of the well leg should be tested out and used as a comparative guide.

Peripheral Paralysis.

Peripheral paralysis is caused by disease or injury of a peripheral neuron. The most common form encountered by the chirop-

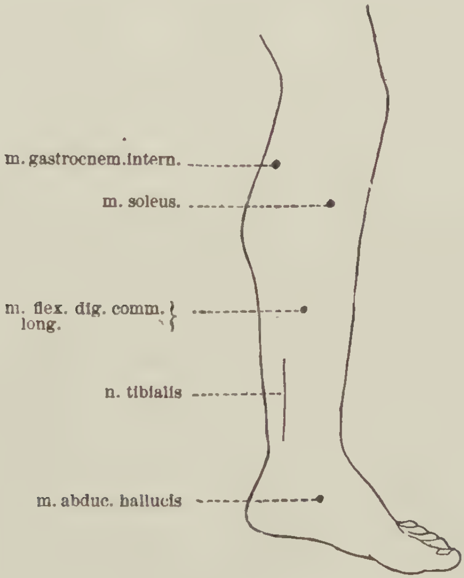

Fig. 45
Motor Points upon Back and Inner Side of Leg and Foot. Muscles (m). Nerves (n).

odist is that following **acute anterior poliomyelitis,** commonly known as infantile paralysis. These cases occur mostly in young children although they may occur at any age. Acute poliomyelitis is an infectious disease that involves the spinal cord, most frequently the cervical and lumbar portions. As a rule the anterior, or motor horn of the cord is involved, the nerve cells of which are injured or entirely destroyed by the toxic action of the virus or by the mechanical effect of the disease. The lower extremities are more frequently paralyzed than the upper and one limb is more

frequently affected than both limbs. The anterior thigh muscles are more frequently involved than the posterior, the anterior leg muscles than the posterior and the adductor muscles of the foot than the abductor group. Three distinct types are recognized—acute, subacute and chronic, although but two are usually seen, the acute or infantile paralysis and the chronic or progressive muscular atrophy of adult life. The chronic form is not infectious.

The cases seen by the chiropodist are generally those of the

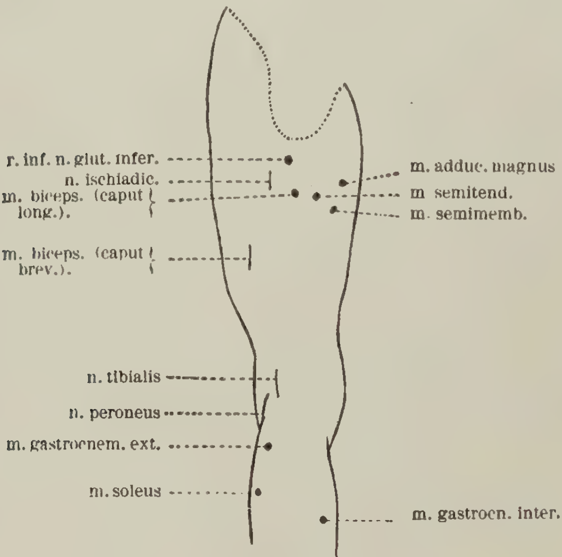

Fig. 46

Motor Points upon Back of Thigh and Leg.
Muscles (m). Nerves (n).

acute type which have recovered from the constitutional effects of the disease and exhibit more or less loss of function in the foot and leg. In many instances no definite history of illness can be obtained, or possible only a history of a slight indisposition followed in a short time by noticeable paralytic symptoms. Very frequently the case will be brought to the chiropodist for the correction of certain foot deformities, as a slight drop-foot or talipes equinus, or later in life a contracted or hollow foot with weakened anterior leg muscles.

Cases exhibiting complete paralysis of one or more muscles are self evident, while a partial paralysis of a muscle or group of muscles, if slight, may be overlooked due to accommodative changes in the leg and a compensating gait. These are the cases in which muscle testing comes into play, not so much for the detection of paralysis as the determination of its degree.

Fig. 46A

Muscle Nerve Testing with the Rapid Sinusoidal Current. The Large, Felt, Indifferent Electrode Is Bound over the Popliteal Space and the Small Testing Electrode Applied over the Motor Point of the Tibialis Anticus Muscle. Note Adducted Position of the Foot as the Muscle Reacts to Electrical Stimulation.

Injuries affecting the peripheral nerves may also cause paralysis, but irrespective of the cause the general treatment is the same. First, diathermia to increase the blood supply to the limb and thus increase metabolic changes in the diseased nerves as well as the surrounding tissues. Second, gentle massage and passive motion for the same reason. Third, the production of muscular contractions by the use of the sinusoidal current.

Treatment of peripheral paralysis.

After the degree of nerve degeneration has been determined by electric testing and comparison with the well limb the diathermia current should be used daily or several times a week. One electrode should be placed over the spinal end of the degenerated nerve or nerves and the other in the saline foot bath in which the foot is placed. The sedative technic should be used to the point of toleration for at least half an hour. This application should be followed by daily massage, consisting of gentle effleurage. These treatments should be continued in an effort to nourish and assist in the regeneration of the diseased nervous tissue until the muscles respond to electrical stimulation by prompt and well defined contraction. When this has been accomplished, *and not until then,* should the muscles be exercised by electrical means. This consists in the use of the **slow sinusoidal current.**

One electrode should be placed over the sacral plexus, or if the paralysis does not extend above the knee, over the popliteal space. The other smaller, or active, electrode is placed over the motor point or points of the paralyzed muscles. The machine being regulated to deliver about 20 sine waves per minute gradually increase the current until slight muscular contractions take place. Produce about five or six muscular contractions and no more; it is unwise to over-exercise a weakened muscle. Follow this with gentle stroking massage. At the next treatment use a little stronger current and produce two or three more contractions. Gradually increase the strength of the current and the number of contractions as the treatments progress, never to the point of tiring the weakened muscles. After each diathermia application a sinusoidal treatment and massage should be given daily. When strong muscular contractions have been obtained the slow sinusoidal mode may be followed by two or three minutes of the rapid sinusoidal for its tonic and stimulating effect.

In sub-acute and chronic cases where the paralysis is but partial and voluntary motion is possible, but limited, the slow sinusoidal may accompany diathermy from the beginning of the treat-

ment. Where the diathermy current is not available radiant light or the infra-red rays may be used for their thermic action. In acute poliomyelitis general tonic treatment of the limb by the air-cooled mercury vapor lamp is very beneficial.

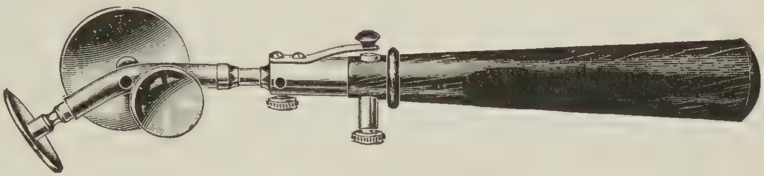

Fig. 48
Interrupting Handle, with Three Discs for Nerve or Muscle Testing.

Neuritis.

Neuritis is a distinct inflammation of a nerve. It presents two clinical forms, i. e., multiple and localized. Either form may be acute or chronic.

Multiple Neuritis is an inflammatory and degenerative affection attacking a number of nerves simultaneously, or in rapid succession, upon both sides of the body, and characterized by pain, excessive sensitiveness of the skin, wasting and loss of motion of the muscles, and often complete paralysis of the muscles controlled by the diseased and degenerated nerve. It is more common than localized neuritis and usually runs a sub-acute or chronic course.

Multiple neuritis is due to general causes acting upon the nervous system as a whole. These causes may be thermic—as exposure to heat or cold; or chemical poisons—as alcohol, lead, arsenic, phosphorus, anilin, illuminating gas, mercury, etc.; or again there may be a general infection or intoxication as the result of an existing or pre-existing disease. Diphtheria, septic conditions, meningitis, rheumatism, syphilis, gout, diabetes, scarlet fever, small pox and influenza are frequently followed by multiple neuritis.

Alcoholism is the most frequent cause of this disease, producing very conservatively, two-thirds of the cases; while of the diseases diphtheria is most frequently the cause. The disease may begin suddenly with fever, pain and muscular weakness, but this is not

the rule. Usually it begins gradually, the symptoms growing worse over a period of several weeks. These symptoms are frequently referred to the feet and legs and consist of numbness, slight pains and weakness, which rarely extend much above the knees. The muscles and nerves are very tender. The fingers, hands and arms are often similarly affected, but to a lesser degree. At the same time the skin becomes reddened or slightly oedematous; the muscles of the leg grow weak and in a short time the patient may be unable to stand. In a week or two there may be a complete loss of power in the front muscles of the leg and a lesser degree of paralysis in the extensor muscles of the hand. Nearly all the leg and fore-arm muscles eventually become involved. Atrophy of the muscles sets in at the same time and very severe pains are present.

When the disease is fully developed, which is within two or three weeks, there is paralysis of the lower extremities with "foot drop", some degree of "wrist drop", marked wasting of the muscles and slight oedema of the feet. The skin reflexes are often absent, the knee jerk and elbow jerk always lost.

The paralysis of multiple neuritis is characteristic, in that all four extremities are involved. The special characteristic is the "foot drop", which is indicative of alcoholic neuritis, just as "wrist drop" is of paralysis from lead poisoning. The prognosis of this disease depends upon the general condition producing it.

Localized Neuritis.

Definition. Localized neuritis is a true inflammation of a single nerve trunk, or a few adjacent nerve trunks. It may be acute or chronic.

Etiology. Acute localized neuritis is most frequently caused by traumatism. The injury may result in sudden tearing, cutting, stretching or compression of the nerve, with consequent inflammatory reaction; or it may consist in continuous pressure as exerted by dislocated or misplaced bones, foreign bodies, tumors, bony over-growth and spurs, or tight bandages and splints.

An infective or septic process in surrounding tissues frequently extends to a nerve trunk, causing a neuritis. Such a condition may

be traced to a septic corn, callus, ulcer, or to a suppurating wound upon the foot or leg. Exposure to extreme heat or cold may also produce a true inflammation of a nerve. A severe attack of chilblains is sometimes followed by neuritis.

By far the most common cause of local neuritis in the foot is pressure due to deformity. Depression of one or all the heads of the metatarsal bones is probably the most common cause, inasmuch, as it is one of the most common deformities. In this deformity the depressed bones pinch or make direct pressure upon the branches of the plantar nerves, which frequently results in an inflammatory condition. The paroxysmal pain of Morton's neuralgia frequently becomes continuous, due to the fact that constant pressure has finally inflamed the nerve proper and that the pain is no longer neuralgic in character, but neuritic.

Displaced sesamoid bones may also cause a neuritis by exerting pressure upon the terminal branches of the internal plantar nerve, while the deformity of hallux valgus may injure the musculo-cutaneous or internal plantar nerve. The numbness so often observed along the ball and inner margin of the great toe is frequently a symptom of a pressure neuritis of the nerves supplying that member although it is more likely due to pressure upon the sensory nerves. Likewise the pain, burning or numbness experienced in the ends of the lesser toes may be due to a pressure neuritis, due either to local or constitutional causes, frequently the latter.

Partial dislocation of the bases of the metatarsal bones at the tarso-metatarsal joints, especially of the first metatarsal bone, due to wearing high heeled shoes and resulting in a "buckling" of the instep, frequently causes a pressure neuritis of the musculo-cutaneous nerve. The abnormal pressure exerted by a flat-foot, plus the tense, stretched plantar fascia and the jarring heel walk, is a common cause of plantar neuritis.

The external popliteal nerve may be injured as it bends around the fibula and a neuritis of this nerve is not infrequent in those who work in a kneeling or crouching position, due to compression of the nerve between the fibula and the tendon of the biceps muscle.

The internal popliteal and posterior tibial nerves are less liable to injury owing to their deeper course.

Chronic localized neuritis may follow an acute attack from any of the preceding causes in which recovery has not taken place, the condition being sub-acute or chronic. Or it may be produced by alcoholism, gout, rheumatism, syphilis, diabetes, or one of the acute fevers. This condition is frequently seen during convalescence from diphtheria, typhoid fever, influenza, etc. In rare cases a sciatica may terminate in a severe plantar neuritis.

Pathology. In acute neuritis there is a hyperemia of the nerve sheath and surrounding tissues, sometimes with extravasation of blood into the nerve substance and oedema of the sheath from the exudation. The pain of neuritis is due to this swelling of the nerve within the sheath.

In the chronic form there is an increase of the connective tissue in and around the nerve trunks, a fibrosis, which contracts and causes atrophy and degeneration of the nerve fibres, thus producing functional paralysis of the parts supplied by the nerve.

Symptoms. Acute local neuritis usually commences as a vague sensation of unrest and discomfort in the affected part, with numbness and tingling, which soon develops into a deep seated aching pain following the course of the affected nerve. The pain is continuous, unrelieved by position or posture, worse at night, very sensitive to pressure or friction and increased by motion.

If the affected nerve is superficial it can be traced by a continuous or interrupted swelling along its course, which is sometimes marked by a red line of congestion. There may be a rise in temperature in the affected tissues. The pain may be referred to adjacent nerves and often changes from one portion of a nerve to another, especially under local treatment; as for instance, upon the application of heat or electricity. In certain foot cases the disease ascends and involves the larger nerve trunks of the leg, constituting the so-called "ascending" type of the disease.

Neuritis of the plantar nerves is more common than that of the dorsal nerves and due to its deep location frequently exhibits few

local symptoms, save that of hyperaesthesia and pain. Acute cases failing to terminate favorably usually run into sub-acute or chronic conditions, in which the hyperaesthesia is replaced by anaesthesia, loss of muscular action, partial or complete paralysis of the muscles controlled by the affected nerve, and atrophy.

There is a disease of the vaso-motor nerves known as **Erythromelalgia** in which plantar neuritis is a constant feature. This disease affects the feet chiefly and is characterized by burning pains and congestion of the parts. It occurs usually in men of middle life after a low fever or severe foot exertion, beginning in the ball of foot or heel with a pain, which is worse at night. This increases until nearly the whole sole in the distribution of the plantar nerve is involved and the pain is almost continuous. It is increased by exertion, the feet become tender and standing or walking is painful. A flushing of the part develops upon exertion, which may assume a dull, dusky, mottled redness. This disease is very chronic and its cause unknown.

Treatment.

The first indication in the treatment of neuritis is to determine if possible the cause and remove it. If the disease is due to a general systemic intoxication as a result of disease or poison an effort should be made to clear this up. If an infected area exists drain and treat antiseptically. If pressure is exerted upon the diseased nerve by a misplaced bone, over-growth or deformity correct the deformity and relieve the pressure.

Heat is the best agent in the treatment of *acute* neuritis and of the various forms of heat diathermia stands first. If applied early inflammation will be lessened, the exudate absorbed and fibrositic changes less likely to occur. In applying diathermia the electrodes should be placed in such a manner that the entire path of the nerve is traversed by the heating current. If the neuritis is localized in one or more nerves of the foot place one electrode over the periphery of the nerve, or as near it as possible, and the second electrode over the main nerve trunk at or about the popliteal space. Should the pain extend above the knee it will be necessary to place it over

the great sciatic nerve upon the upper thigh or over the sacral plexus. Where a more general heating of the foot is desired the sole may be placed in one-half of water and cuff electrode just above the knee.

The sedative technic should be used from one-half to one hour and repeated daily if possible. Pain is frequently increased for a short time following a diathermia treatment and it is well to so advise the patient. Visible light exposure of 30 minutes is the next best modality to use. An intense application should be given, using the full heating power of the reflector and changing its position momentarily when the heat becomes intolerable. The infra-red ray may also be used as a heat producing modality and continued for long periods. As a home treatment hot foot baths (100° to 104° F.) may be used. The ultra-violet ray frequently gives excellent results in the treatment of acute neuritis. It may be used as a tonic treatment with the air-cooled lamp at a distance of from 36 to 40 inches from the skin, or where a decided counter-irritating action is desired it may be applied at a target skin distance of 8 inches from 1 to 10 minutes. Positive galvanism is also used in this condition for its sedative action. As in diathermia the electrodes should be so placed as to include the entire path of the affected nerve within its circuit. A mild current should be used for 15 minutes. Ionization of sodium salicylate (1% sol.) is another technic frequently employed. The solution should be applied under the negative pole, in order to drive in the salicylic ions, for 15 minutes, when the poles should be reversed for a few minutes. Gentle massage may be used in acute neuritis the motion being limited to effleurage, but no deep massage, manipulation or vibration should be employed.

Chronic localized neuritis is best treated by diathermia, for the reason that a certain degree of fibrosis always exists in these cases and its disintegration and absorption is more surely accomplished by this modality than any other. Treatments should continue from 30 to 60 minutes. Negative galvanism is also of benefit in these chronic cases on account of its softening action upon fibrous tissue. The interrupted sinusoidal current may be used as a tonic applica-

tion at the termination of each treatment. In those cases of chronic neuritis in which the nerve involvement produces a partial paralysis of the muscles which it supplies the slow sinusoidal current should be employed as described under peripheral paralysis.

Neuralgia.

Neuralgia is a functional disorder of a nerve. It is caused by exposure to cold; traumatism; a lessened supply of blood to the nerve (a local anemia) or an impoverished condition of the blood itself; or to a toxic condition. In the foot and leg it is most frequently the result of traumatism or pressure, although it is frequently an outstanding symptom in thrombo-angiitis obliterans. Pain is the cardinal symptom. This may extend throughout the course of the nerve but is most frequently referred to the terminal filaments. Neuralgia must be differentiated from neuritis, with its inflammatory symptoms and localized tenderness along the affected nerve, as well as the pain found in muscles upon pressure in myalgia.

Plantar neuralgia or *plantalgia* is a neuralgic pain referred to the sole of the foot with tenderness of the plantar fascia upon pressure or stretching. This condition may follow an attack of one of the infectious diseases, but is most frequently associated with the hollow or contracted foot in which the tense plantar fascia exerts pressure upon the nerve, or acts mechanically to produce an anemia.

Treatment of neuralgia.

Long wave ultra-violet ray treatments are especially indicated in neuralgia, especially of an acute character. Short, mild applications of radiant light or the Oudin current applied over the painful area are also indicated. Positive galvanism is of undoubted value in early cases, while negative galvanism is indicated in chronic cases. Diathermia may be used in early cases but due to the active hyperemia produced will exaggerate the pain. It is better to use a low degree of radiant light or a sedative high frequency treatment in these cases and employ diathermia only in chronic cases in which a decided fibrosis exists. Diathermia is almost sure to increase the pain temporarily in either case. Massage and vibration is contra-

indicated. The pain of plantar neuralgia as found in hollow foot is generally relieved by visible light and the application of a strapping which will relieve the tension upon the plantar fascia and distribute the body weight uniformly from heel to ball.

Disorders of Sensation.

When nervous functions are disordered there is an increase, decrease or perversion of the special function or activity. The following sensory symptoms are those most commonly found in the foot.

Anaesthesia is a loss of tactile sensibility, and is often used with a general meaning to indicate loss of all forms of sensibility.

Hyperaesthesia is an excessive sensibility to touch or contact.

Hyperalgėsia is an excessive sensibility to pain, and is nearly identical with tenderness.

Paraesthesia is a term applied to all the morbid general sensations except pain. It includes such feelings as numbness, prickling, flushing or burning, itching, tickling, coldness, etc.

The cause of sensory symptoms may be toxic or traumatic. Frequently such symptoms accompany a localized neuritis or they may be a localized manifestation of a general condition. As found in the foot they are most frequently caused by pressure, either from an ill fitting shoe or the pressure exerted upon nerves lying over prominent surfaces or deformities. The dorsal nerves are more frequently affected than the plantar, due to their superficial location. A tightly laced shoe, the strap of a pump, or a tight skate strap frequently results in morbid sensory impressions. Numbness of the great toe is frequently associated with chronic bunion, while hyperaesthesia is a common symptom of injury to the dorsal nerves. Burning, prickling or coldness is associated with vaso-motor disturbances, either of local or general origin.

Treatment.

The interrupted sinusoidal current is of especial benefit in sensory disturbances. One electrode should be applied to the distal extremity of the nerve affected and the other high up the leg. Mild applications of negative galvanism may also be made to anaesthetic

areas, while positive galvanism should be used in hyperaesthesia. Rapid faradic applications are also of advantage in these cases. Mild visible light treatments are useful, followed by cold douches or sprays. The alternating hot and cold foot-bath is also used for its stimulating effect.

DISEASES AND INJURIES OF BURSAE, MUSCLES AND TENDONS.

Bursitis.

Bursae are sacs filled with fluid found in various places where friction or pressure occurs between different layers or structures. They are sometimes divided into synovial and mucous bursae. The former are for the most part placed beneath a muscle or tendon and a bone, or the exterior of a joint. The latter are found beneath the skin and some firm prominence beneath it. Synovial bursae may be of different forms and often communicate with a joint, being involved in joint disease. The most common location of bursae upon the foot is as follows: 1. The Achilles bursa, situated between the insertion of the tendo-Achilles and the posterior tubercle of the os calcis. 2. Subcutaneous heel bursa, found just beneath the subcutaneous tissue and the insertion of the tendo-Achilles. 3. Tibialis anticus bursa, placed beneath the insertion of the tendon of this muscle and the surface of the internal cuneiform bone. 4. Tibialis posticus bursa, between the lateral tendinous expansion of the tibialis posticus muscle and the surface of the scaphoid and the second cuneiform bone. 5. Tarsal sinus bursa, situated in the fat that fills up the tarsul sinus between the os calcis and the astragalus upon the lateral aspect of the toot. 6. Lumbrical bursae, are found between the tendons of insertion of the lumbrical muscles and the bases of the phalanges. 7. Metatarso-phalangeal bursae, are almost constantly found between the heads of the first three metatarsals. 8. Subcutaneous bursae are found between the subcutaneous tissue and the bone of the inner and outer malleolus and the posterior tubercle of the os calcis.

Adventitious or abnormal bursae may develop wherever long continued friction or pressure is exerted. The most frequent site is the metatarso-phalangeal articulation of the great toe; over the

fifth metatarso-phalangeal articulation; the scaphoid tubercle; over the joint formed by the base of the first metatarsal and internal cuneiform, and also between the inferior tubercle of the os calcis and the plantar fascia—the so-called calcaneal bursa.

Etiology.

Bursitis may be traumatic, infectious or tuberculous. Bursitis of the foot is most frequently of traumatic origin, although in many cases a focal infection may be the cause and upon its elimination the bursitis at once subsides. Bursitis of the first or fifth metatarso-phalangeal joint is usually the result of pressure from a tight, pointed or short shoe which causes the great toe to abduct, or the fifth toe to adduct, and results in a prominent deformity upon the inner or outer surface of the joint, as the case may be, and a localization of pressure and friction over the bursa. Hallux valgus is usually accompanied by a bursitis for the same reason. A bursitis in this region is known as a **bunion** and may be either acute or chronic.

Calcaneo-bursitis is an inflammation of the bursa lying between the periosteum and the fatty tissue upon the under surface of the heel near the inner tuberosity of the os calcis. It is frequently caused by long standing or the impact of the heel in the jarring heel walk of flat or weak-foot. These cases have been known as "policeman's heel." A gonorrhoeal infection of this bursa is frequent, giving rise to acute inflammatory and painful symptoms. In cases of long standing it may result in an exostosis or spur at or about the origin of the flexor brevis digitorum muscle.

Achillo-bursitis is an inflammation of the bursa lying between the insertion of the tendo-Achilles and the os calcis. It may be due to a strain of the tendon, to the friction produced by an ill fitting shoe or as a complication of chilblain occurring at this point. Again, Achillo-bursitis may be of toxic or tuberculous origin.

Symptoms.

The important symptom of acute bursitis is pain, localized about joints or certain tendons, attended with redness of the skin, oedema and characteristic globular swelling. The inflammation is

of the mechanic variety and is usually recurrent. In chronic bursitis or bunion the swollen, distended bursal sac may be replaced by a fibrous enlargement, the seat of frequent inflammatory attacks. Where infection occurs there is an increase of pain, throbbing and all the signs of an infective process; and where a bursitis complicates an arthritis, synovitis or tendo-synovitis the symptoms are those of a general inflammation of these structures.

Pathology.

In mild acute cases the lining membrane of the bursal sac is simply congested and the cavity contains serous fluid. In more acute cases the sac becomes enlarged, distended and filled with synovia. This enlargement produces increased pressure and a corn or callosity usually develops. If the bursa be much enlarged, when the corn is removed an exudation of synovia may occur. This is the most frequent source of septic infection which may go as far as to involve the joint cavity. A sinus often develops leading to the surface through which pus mixed with syonvia is discharged. In chronic cases the walls of the sac are much thickened, the lining membrane is fringed and thrown into folds and the contents become gelatinous or semi-solid. In some cases this process continues until the entire bursa becomes organized and fibrous, again it may become calcareous by the deposit of lime salts. In cases of long standing parts adjacent to the bursa, as the expanded attachment of tendons and the periosteum, become thickened, so that the bone appears to be thickened and enlarged. This is especially noticeable in Achillo-bursitis.

Treatment.

Early, acute bunion is best treated by the Oudin or Tesla high frequency current with a small, flat, surface condenser electrode. A mild current, one-quarter inch spark, should be used over the surface of the joint and surrounding tissues for 5 minutes. Follow this with rapid, short stroke vibration applied gently about the bursa for 2 or 3 minutes and complete the treatment with the application of gentle effleurage. Dress with half-moon, cut-out shield, points down, held in place by a circular strapping.

Where the great toe is abducted and motion considerably restricted use a deeper, longer vibratory stroke, the soft rubber disc applicator being applied under the joint while the toe is held in as straight a position as possible. This will do much to relax the joint and may be followed by a short, rapid, sedative vibration for a minute or two.

The ultra-violet ray is of decided benefit in acute inflammatory cases. Use the water-cooled lamp at a distance of one-half inch for one or two minutes, daily to twice a week.

Chronic bursitis or bunion, with fibrosis, is best treated by diathermy or visible light. Where diathermy is used the foot should be inclined and titled in such a manner that the affected joint rests in one-half to one inch of salt solution. One electrode is placed in the water bath near the joint and the other upon the outer side of the dorsum, diagonally across the foot. Thus the conversive heat will be localized within the bursal tissue and its softening and absorbing effect secured. Treatment should persist for at least 20 minutes. When visible light is used the adjacent parts should be covered with a towel and as intense heat as can be tolerated directed upon the bursal enlargement. Application of the non-vacuum condenser electrode will produce high superficial heat and may be used where other heating modalities are not available. In all cases vibration should be used below and around the joint after it has been subjected to heat in an effort to obtain relaxation and increased joint movement.

Negative galvanism, for its softening effect, is also used to follow diathermy or visible light. A small, flexible mesh electrode may be laid over the bunion and the negative terminal clipped to it, while a larger, felt, positive electrode is placed upon the opposite side of the foot. (See Fig. 3A.) From 3 to 5 ma. should be used for 10 minutes. A better application consists in moulding a pack of potter's clay over the bunion and covering this with wire mesh to which is clipped the negative terminal. Where potter's clay is not to be had plain talc moistened with water and a little glycerine to the consistency of putty will serve the same purpose.

Ionization of sodium chloride may be obtained by using salt solution to moisten the clay or talc.

Calcaneo-bursitis is best treated by diathermy. The heel should be placed in one-half inch of salt solution, in which one electrode is placed; the other electrode consisting of a plate or cuff should be applied about four inches above the ankle. (See Fig. 43H.) Treatment should consume from 20 to 30 minutes.

Achillo-bursitis may be treated in the same manner, using a plate, rather than a cuff electrode, upon the posterior surface of the leg, about four inches above the ankle. Visible light or the non-vacuum condenser electrode may also be used over the inflamed bursa. The actinic rays from the water-cooled lamp, used in contact or at a distance of one inch, is good treatment, especially in those cases accompanying chilblains at this point.

Inflammation of adventitious bursae is treated along the lines just laid down. In those cases occuring upon the phalangeal joints in which a flattened bursa under-lies a corn or callus, with but a small amount of synovial fluid present, dessication produced by the mono-polar Oudin current may be used to encourage adhesion of the walls of the sac and its absorption. After the corn or callus is removed the bursa should be stretched between the thumb and finger in an effort to bring the walls of the sac together and while it is held in this position the dessicating needle should be touched to the surface at various points. A very low current should be used, just enough to produce mild dessication, without heat or burning of the tissues.

Tendosynovitis.

Etiology. Inflammation of the synovial lining of tendon sheaths is due to either injury or infection. It may be acute or chronic.

Acute, simple tendosynovitis is due to strain, pressure or overuse. Frequently it is associated with Achillo-bursitis or chilblains, where the latter affect the back of the heel over the insertion of the tendo-Achilles. Pain and fine crepitus are the distinctive signs. Dense and troublesome adhesions may be formed in cases of severe injury, especially when associated with fractures about the ankle.

Chronic simple tendosynovitis is characterized by effusion into the sheath without pain. It is uncommon in the foot.

Acute suppurative tendosynovitis is due to infection through wounds, from nearby infected areas or complicates any of the infective inflammatory diseases. Unless drained the infective process is extremely liable to extend throughout the entire tendon sheath and involve neighboring joints or bones. Fibrous adhesions are quite the rule.

Chronic tuberculous tendosynovitis consists in a formation of pulpy granulation tissue within the sheath and increased fluid, so that a flucuating, painless swelling is formed. Again, melon-seed bodies, consisting of fibrin, together with fluid, are present and distinguished by the presence of a peculiar crepitus.

The most common location of tendosynovitis in the foot is in the sheath of the tendo-Achilles and the extensor and flexor longus hallucis.

Treatment.

Diathermia is the best treatment. When the tendo-Achilles is involved the heel should be placed in a foot bath in which is placed one electrode, while the other consisting of a plate, 2 x 4 inches, should be bound over the calf of the leg at about its middle. Heat should be used to the point of toleration for 15 minutes. Visible light is also therapeutic value when directed over the inflammed area for 15 or 20 minutes. The application of the Tesla or Oudin current by means of a condenser electrode is indicated in simple, acute cases, employing a low, sedative dosage for 15 or 10 minutes; gradually passing the electrode back and forth over the tendon and adjacent tissues. Heat in any form should not be used in suppurative cases until drainage has been established.

The ultra-violet ray from the water-cooled lamp may be used locally to limit the spread of the disease in acute cases and to encourage absorption of adhesions in chronic cases.

Strain of the Tendo-Achilles.

As a result of strain or over-use this tendon is frequently injured and while the symptoms may simulate those of a tendosyno-

vitis or Achillo-bursitis yet examination will demonstrate the pain and swelling to be in the tendon itself. The point of strain may be at junction of the tendon and the muscle, but usually it is about the middle of the tendon.

Treatment.

Visible light over the painful part, or diathermia applied by cuffs above and below the seat of injury or lateral plates, is the rational treatment. The heat produced by the non-vacuum condenser electrode is of great value in these cases and easy of application.

Torn Muscle Insertions.

These injuries follow sudden, violent exertions, such as used by the sprinter or jumper. Visible light, diathermia applied by the double cuff method and the Oudin and Tesla current comprise the best methods of treatment. The muscle should be completely relaxed in extension before the application of heat and no muscle stimulating or exercising current should be used until the muscle attachment is again secure. Massage may be used gently at first and with gradually increasing force as the tissue repair progresses.

Rupture of Plantaris Tendon. (Lawn Tennis Leg.)

Rupture of this thin, long tendon frequently occurs as a result of a mis-step, a sudden jump or forced rising upon the toes, especially in middle aged individuals or those in which there is more or less spasticity of the calf muscles.

The symptoms are calf pain when the foot is dorsal flexed and localized pain over the seat of rupture, usually about the middle of the calf, upon pressure. At times the point of injury may be localized by the indurated tissue which forms between the ends of the ruptured muscle fibres. Swelling is slight but there may be localized ecchymosis.

Treatment.

Diathermia, applied by the double cuff method, is the best treatment. Visible and gentle massage is also of value. The foot should be fixed in extension until union is complete.

Myositis.

Myositis is an inflammation of muscle tissue and is more frequently found in the extremities. It is usually secondary to an infective process in other parts of the body. The symptoms are of sudden onset and consist of localized pain in a muscle, or a set of muscles, with induration, heat, swelling, redness and pain upon pressure. The inflammation may subside leaving more or less fibrosis or the process may go on to suppuration, with chills, fever and general septic symptoms. A form known as *myositis ossificans* consists of a calcification of the connective tissue of muscles with atrophy of the muscle fibres.

The acute symptoms of myositis are best met by prolonged applications of radiant light or diathermia. Should pus develop surgical intervention is necessary.

Myalgia.

Pain in the muscles starts as an acute condition but may become chronic if untreated. If not due to injury it is caused by sudden muscular contraction which prevents the exit of the fatigue toxins, thus irritating the terminal nerve filaments and producing pain.

The typical myalgia, as lumbago, is seldom seen in the foot and leg, however in acute weak-foot a painful muscular condition is occasionally seen as the result of improper foot posture and muscle tire.

Myalgia is best treated by diathermia, visible light, the Oudin or Tesla high frequency current applied with a non-vacuum condenser electrode and alternating hot and cold baths. The rapid sinusoidal current of mild dosage may be used after heat producing modes.

DISEASES OF BLOOD VESSELS.

Dysbasia Angiosclerotica.

Synonyms. Intermittent limp. Intermittent claudation.

Etiology. The cause of this disease is obscure.

Symptoms. **Pain upon walking** is the cardinal symptom. This pain is more frequently limited to one leg and is brought on by rapid walking, forcing the patient to limp, and usually terminates

in a cramp of the calf muscles which persists until the part is put at rest; to return as soon as locomotion is resumed. This condition is more often found in males of middle or old age and may affect both legs. It is especially prevalent among Jews of Russian, Austrian and Galician nativity.

Pathology. This local leg condition is probably but an exaggerated manifestation of a general arterio-sclerosis, in which the walls of the blood vessels of the posterior aspect of the leg are thickened and sclerosed. As a result of this sclerosis the calibre of the vessels is diminished and consequently a decreased supply of blood is furnished the muscles of the calf. While these muscles are passive the blood supply is adequate, but when they become active, as in walking, they are insufficiently nourished, fatigue toxins accumulate and by their presence irritate the muscle fibres and reflexly produce the characteristic cramp.

Treatment. Physio-therapeutic treatment is that of thrombo-angiitis obliterans.

Thrombo-angiitis obliterans.

Synonyms. Thrombo-arteritis obliterans; Endarteritis obliterans; Buerger's disease.

Etiology. As in the case of intermittent limp the cause of this affection is obscure. Excessive smoking has by some been considered a factor. In this country it is almost entirely limited to young or middle aged male members of the Russian, Galician and Austrian races.

Pathology. Thrombo-angiitis obliterans is an inflammatory disease of the veins and arteries. It begins usually in the blood vessels of the legs below the bifurcation of the popliteal artery and from here spreads in other vessels. It has a tendency to periodic relapses. The pathology is that of an acute inflammatory lesion of the lining membranes of the arteries with an occluding blood clot. This is followed by an organization of the clot, disappearance of the inflammatory products and finally by a periarteritis which may bind firmly together the artery and accompanying vein and nerve.

Unless calcification is present x-ray pictures fail to show a change in the tissues.

Symptoms. These are due to the gradually shutting off of the arterial blood by the occluding clot. The first sign noticed is pain or cramp in the foot or calf of the leg while walking. This is frequently attributed to rheumatism or flat-foot. The pain is relieved when the patient sits down or holds up his leg. This characteristic symptom is spoken of as intermittent claudation. The affected foot takes on a purplish blue color when dependent and blanches white when held horizontally. It feels colder than the other foot and leg and is sensitive to cold, damp weather. The skin is cold and clammy and pulsation in the dorsalis pedis and the posterior tibial arteries is either absent or lessened in volume. There is little or no pain upon pressure.

As thrombosis develops there is atrophy of one or more toes, a darkening of the skin with a dry gangrenous appearance, but differing from other forms of gangrene in the slowness of its progress. In some cases the destruction of a toe may last over a period of years. The dry gangrene usually appears in the great toe and gradually spreads up the leg.

Treatment.

As yet no means of curing this condition have been found. Theoretically diathermia would appear to be an ideal treatment for the sclerotic pathology of this condition but there is considerable diversity of opinion as to its practical worth, to say nothing as to safe application; some practitioners asserting that its use only hastens the process and final gangrene. Others contend that physiotherapeutic treatment may at least accomplish a temporary cessation of the disease if properly used in early cases. The modality which has given the most satisfactory results in thrombo-angiitis obliteran is diathermia, but its application must be started with *very small doses* and increased slightly from week to week. Very frequently the patient will be unable to tolerate more than 100 ma. for the first week and it may be four or five weeks before it is possible to use 500 ma. *A greater dosage than this should not be*

attempted. Intense pain frequently follows the use of diathermia and especially if a high milliamperage is run up suddenly. The foot bath with cuff electrode about the calf is the best method of applying the current to the affected leg. However if the pain experienced by the dependent foot is too great in this position the patient may recline upon a table, face down, with the foot overhanging its edge and the toes resting in a foot bath, while a cuff electrode is placed around the upper part of the calf.

The fibrosis accompanying this condition may also be met by the use of negative galvanism. Gentle massage should be practiced late in the disease.

Phlebitis.

Definition. Phlebitis is an inflammation of a vein. It may be acute or chronic.

Etiology. Traumatism or infection. It may be caused by intravenous injections of various drugs.

Symptoms. Pain and a line of inflammation over the vein if it is superficial. If a deep vein is affected an indurated area may be detected with pain upon deep pressure.

Pathology. That of an inflammation of the lining membrane of the vein with the formation of a thrombus. Should this blood clot become infected and fragments carried by the blood stream a general infection may result. Phlebitis may be associated with an inflammation of the adjoining lymph vessels, producing a lymphangitis. Phlegmasia alba dolens (milk-leg) is a type of phlebitis, limited to the iliac vessels.

Treatment.

Visible light applied to the point of tolerance over the inflammed veins is decidedly analgesic. The ultra-violet ray from an air-cooled lamp may be used to the point of producing regenerative erythema over the area of inflammation. Diathermia if not absolutely contra-indicated should be used with extreme caution, inasmuch as the dilatation of the vessels and increased blood flow produced by conversive heat might result in washing a clot into the

general circulation, producing a fatal embolism. Manipulation and massage is contra-indicated in phlebitis for the same reason.

DISEASES AND EXCRESCENCES OF THE SKIN

Verruca or Papilloma.

Synonyms. Wart; verucca plantaris.

Etiology. Verrucae are caused by an infectious virus which inoculates minute abrasions of the skin. This has been demonstrated and conclusively proven by numerous experiments in which the injection of a filtrable virus reproduced typical verrucae. The fact that these tumors are infectious is still further borne out by the existence of well defined epidemics of verrucae plantaris occuring in those who have frequented the same swimming pools and shower baths. The lesion is found more frequently in females than in males, girls passing through the period of adolesence being especially liable to this affection. Verrucae are frequently multiple, one or more well defined growths being surrounded by many small lesions, ranging from the size of a pin-head to a small bird-shot. Ordinarily when the original, or parent growth is destroyed the small multiple lesions dry up and disappear without treatment.

At times it appears that traumatism, as the localized pressure produced by stepping upon a small, hard object, is the cause of verruca, but this probably is but an exciting cause in which the minute abrasion so produced offers entrance to the infectious virus.

Pathology. Verrucae of all types are the hypertrophy of a number of papillae which push up through the epidermis and downward into the reticular layer of the derma. There is hypertrophy of all the connective tissue cells and an accumulation of hornified epithelium around the hypertrophied papillae, which are very vascular, the capillaries in them being dilated and bleeding very freely upon injury.

The varieties of warts vary as to their location. Upon the feet the plantar surface is the most frequent site and in this location the growth is surrounded and covered by a distinct callus formation, is flattened and deeply imbedded as the result of pressure. Verrucae may occur upon the dorsal surface of the feet or toes, or

between the toes, in which case they are frequently elevated slightly above the surrounding skin; their structure is essentially the same as the plantar variety.

Treatment.

Verrucae or papillomata are best treated by physiotherapy.

Fig. 48A

Removing a Vascular Corn by Indirect Diathermia. The Foot Rests upon a Glass Plate under Which a Block-Tin Electrode, Clipped to one d'Arsonval (Diathermia) Terminal, Is Placed. The Other Terminal from the Machine Is Attached to the Handle Holding the Needle, Which Should Be Held in **Contact with the Growth** or Introduced into It if Necessary. The Same Result May Be Obtained by Seating the Patient upon an Auto-Condensation Pad or Chair Attached to One d'Arsonval Terminal. This Treatment May Be Used in Verruca, Neuro-Fibrous Corns or the Destruction of Granulation Tissue.

Various modalities and methods may be used. Of these the high frequency current is the best modality to use in destroying these growths upon the foot in that the wound produced is sterile, bloodless and that the patient is able to use the foot at once with very little discomfort and practically no danger of subsequent infection. Three methods of using the high frequency current are practiced.

1. Bipolar endothermy or tissue coagulation. 2. Monopolar endothermy or dessication. 3. Monopolar fulguration. The galvanic current may also be used in the destruction of verrucae by electrolysis, while x-ray exposures are also of distinct value.

Bipolar endothermy, also known as electro-coagulation; tissue coagulation; surgical diathermia and surgical endothermia, con-

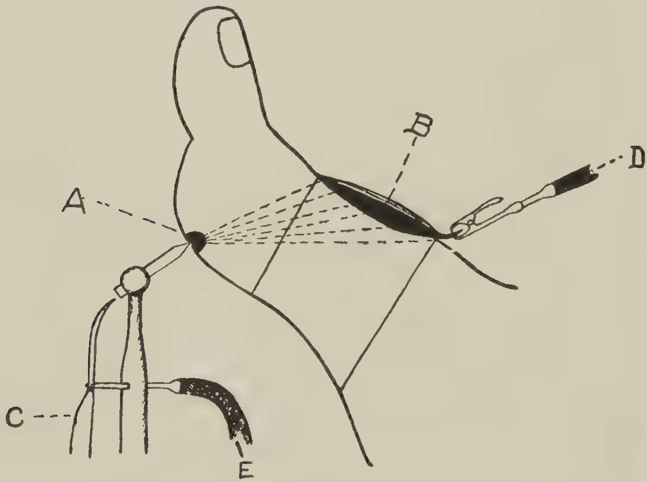

Fig. 49

Destruction of Papilloma by Bipolar Endothermy. A—Papilloma; B—Indifferent Block-Tin Electrode; C—Contact Thumb Piece; D—One Terminal from d'Arsonval Apparatus; E—The Other Terminal from Apparatus.

sists in producing heat within the tissues by the resistance offered by the tissues to the passage of the d'Arsonval or diathermia current. The heat produced in this way does not burn, nor does it char, but coagulates the tissues and thus sears off the lymphatics, blood vessels and sensory nerve filaments. Consequently there is no bleeding and practically no danger of infection. In this method *both poles of the d'Arsonval appliance are always used.* The technic is as follows:

Assuming that the growth is situated upon the ball of the foot at A (Figure 49) the field of operation is rendered surgically clean and the callus and hornified epithelium over and about the verruca removed to a point just short of producing bleeding. A

rounded, block-tin electrode B about the size of a silver dollar is moistened with soap lather and bound tightly upon the dorsum of the foot with a few turns of elastic bandage. This tight, circular bandage not only holds the electrode in place but cuts off the circulation and prevents the absorption of the local anaesthetic into the general circulation. A sterile solution of novocain suprarenin (1%) is now introduced deeply under the base of the verruca by hypodermic injection. Ordinarily about one-half of a 2 c.c. ampule is required. The hypodermic needle should be entered in the healthy skin just beyond the margin of the growth and forced downward and inward under its base. On account of the thickness of the skin upon the ball of the foot no attempt should be made to secure a superficial injection. After the anaesthetization is complete one outlet from the diathermia outfit D should be clipped to the electrode B at a point farthest from the toes. The other outlet is connected to the electro-coagulation needle (Figure 50) or fulguration point (Figure 51). If the former is used it is controlled by a foot switch, while in the latter a thumb switch opens and closes the circuit. For chiropodial use the latter instrument is the best instrument. The diathermia current is now switched on, the fulguration point placed *against* the growth and the current closed by the thumb switch. Immediately the current passes through the foot between the large electrode upon the dorsum and the point of the fulguration needle, the area of greatest concentration being within the tissues beneath the fulguration point and consequently the heat produced at this point is sufficient to coagulate and destroy the morbid growth.

In the destruction of a papilloma the size of a large pea it is well to hold the point of the fulguration needle in contact for an instant at several points about the circumference of the growth and finally to make one application at about its center. As a rule in a growth of this size the entire time consumed should not be more than 5 or 6 seconds. It should be remembered that the destruction of tissue by this method is intense and rapid and it is best to coagulate too little rather than too much tissue; for a second appli-

cation may be made if destruction is found incomplete. The amount of current which is switched on at the machine can not be given, for the reason that machines differ in output and the method of rheostat control. Again, the exact time required for tissue coagulation can not be given. Before attempting this operation the operator should practice the technic upon a piece of beef steak,

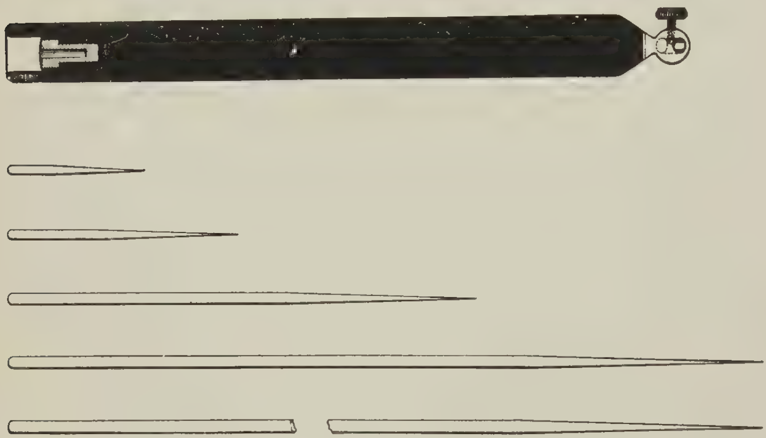

Fig. 50
Electro-Coagulation Needles and Holder.

various current strengths should be used and the depth of destruction produced by each determined by slicing through the burned areas. After the destruction produced by various current strengths has been noted the time required to produce various degrees of coagulation may be ascertained. By these experiments it is an easy matter to establish a technic which will be accurate and efficient. It must be remembered that with a given current strength and time period the destruction is greater in living than dead tissue (beef steak). After the growth has been destroyed it may be dissected out in one piece and if properly and thoroughly done will leave a clean, bloodless wound extending down to the cellular tissue.

The wound should be dressed as any other burn, using a protective pad of several thicknesses of gauze or lint, entirely covered

by adhesive plaster straps. The use of mercurochrome has been found of especial value in the after treatment of these burns. Ordinarily there is more or less serous oozing from these wounds, as in other burns, and the dressings should be changed every day or two. The patient may be allowed to use the foot immediately, the wound usually healing in from ten days to two weeks.

Bipolar endothermy is the best method in large or deep seated verrucae. In small superficial growths, or those occuring secondarily about the parent growth, known as multiple verrucae, the dessication method should be used.

Monopolar endothermy or **Dessication** should not be confused with either bipolar coagulation or fulguration. Dessication devitalizes by *drying* the tissues. The electric current used in this method is not hot enough to carbonize but is of sufficient heat to cause rapid dehydration of the tissues, rupturing the cell capsule and converting the area into a dry mass. The monopolar *Oudin or Tesla current is always used* in this method, the former being much better than the latter. The strength of the current used should not be greater than is necessary to produce a spark one-sixteenth or even one-thirty-second of an inch long. This may be tested by bringing the fulguration point, which should be a fine aluminum needle, the size of an ordinary cambric needle, near a metallic object and noting the length of the spark produced.

If the growth is large it may be necessary to anaesthetize the part as previously indicated, but if small and superficial the discomfort will be so slight that the average patient will be able to withstand it and the pain caused by a novocain injection eliminated.

In dessication the needle must be *applied to the surface* of the verucca, or it may be gently pushed into the tissues as devitalization progresses. Application should be made at various points about the surface of the growth and sufficient time should be consumed to thoroughly dry and harden it. This may be determined by the sense of touch, which will establish the fact that the entire area is dry, hard and scab-like. When dessication is complete the entire area will glow like an incandescent lamp as the current

passes. The site of operation should be dressed by a protective lint or gauze pad held in place by adhesive plaster straps. The dessicated tissue should be scraped or cut away in about a week's time. Occasionally a serous fluid accumulates under the dessicated tissue, in which case the devitalized growth should be at once excised and the wound treated as an ordinary burn.

Indirect dessication is a modification of the preceding method and is performed by placing the patient in a condensation chair or upon an insulated condensation pad to which is attached one outlet of the *d'Arsonval* machine, with the other outlet connected to the fulguration point. Or the foot may rest upon a small sheet of glass under which a block-tin electrode is placed. One D'Arsonval terminal is attached to the electrode and the other to the fulguration point. The needle is then held against the growth at various points and the devitalization is accomplished as just described. This method has no advantage in chiropody over monopolar endothermy.

Direct Fulguration is produced by the use of the Oudin or Tesla high frequency current applied with one pole of the machine attached to a fulguration handle holding the needle. The Oudin current is better than the Tesla current in that the spark produced is "colder" and less painful. This method consists in spraying a shower of electric sparks upon the verruca. The strength of the current employed should be sufficient to throw a spark one-fourth of an inch or longer. Unless used in very small, superficial growths it will be necessary to use local anaesthesia as fulguration is painful and to be successful must be thoroughly done. By this method a direct burning of the growth is accomplished from without inward and necessarily an eschar forms upon the surface which the heat must penetrate in order to destroy the deeper structures. Due to this fact the tissue destruction is not as complete as that produced by dessication, while the discomfort is much greater. Fulguration for this reason has been displaced by the monopolar dessication and its use is not generally advised.

Surgical Electrolysis is produced by the distinct chemical action

of the *galvanic* current. Either pole may be used for the destruction of small morbid growths but in the removal of verrucae the negative pole is generally used in preference to the postive inasmuch as the softening action of negative galvanism is to be preferred to the hardening effect produced by the positive pole. In removing a verruca by this method the part is prepared as previ-

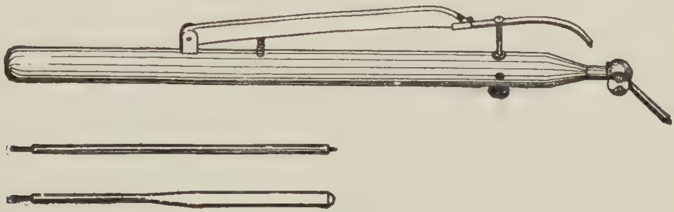

Fig. 51
Fulguration Needle and Holder.

ously directed and local anaesthesia produced, for the use of the galvanic current in this manner is decidedly painful. A large felt or gauze electrode, moistened with salt solution, is bound upon the dorsum of the foot and connected to the postive pole of the galvanic battery. To the *negative* pole is connected a needle holder carrying a small, quarter-curved needle which is entered at the junction of the growth and the healthy skin, or slightly beyond it, passed deeply downward and then upward through the base of the verruca until its point almost punctures the skin upon the opposite side of the growth. The current is then slowly switched on until the milliameter registers from 3 to 5 milliamperes. Minute bubbles of hydrogen will be noticed at the point of puncture and the growth will change color, becoming grayish or pearly white. The current should be allowed to flow for a minute or a minute and a half, when it should be switched off. The needle is now *almost* withdrawn and again pushed through the base of the growth, but in a different direction. Another application of a minute should be given, the needle is again almost withdrawn and inserted in another direction and another application of from 3 to 5 ma. given for one minute. This should be repeated until the entire growth has been

included by the fan-like series of punctures, which all start from the original point of entry of the needle.

The wound should be treated with an antiseptic ointment, a gauze or lint dressing applied and the patient directed to return in a day or two for a subsequent dressing. As a rule there is oozing for a day or two after which a scab forms which separates in a week or ten days. At times it may be found necessary to scrape out the destroyed tissue and treat as an open wound.

This method has largely been superseded by bipolar and monopolar endothermy.

Pernio.

Synonyms. Dermatitis calorica; dermatitis congelationes; erythema pernio; chilblains; frost-bite.

Definition. Chilblain is a local cutaneous affection produced by exposure to cold and dampness just short of freezing. Frost-bite is a more severe inflammation of the skin and deeper structures produced by extreme cold.

Symptoms. These vary with the severity of the exposure. In very mild cases the only symptoms are a slight redness, tingling, itching and a coldness of the part to touch. More severe cases exhibit a purple discoloration which changes to scarlet after reaction sets in. There is inflammation, swelling, itching and pain, especially when the part is heated. There is no sharp line of demarcation between the inflammed and the normal skin. In the more severe types blebs and blisters may form discharging serum or even pus when opened.

In frost-bite numbness and loss of sensation take place soon after exposure to intense cold. If there is complete freezing the tissues are white and blanched and if reaction fails to take place they become gangrenous. If, on the other hand, freezing is not complete, reaction occurs, the tissues become swollen, purple and very painful. Blebs, blisters and ulceration may follow. As resolution takes place the purplish color changes to a redness and the inflammatory symptoms subside. There is frequently a well marked line of demarcation between the healthy and the normal tissues.

Chilblain and frost-bite are prone to reoccur upon exposure to cold and dampness.

Pathology. Chilblain is by some considered a local manifestation of a constitutional condition. Diminished coagulability of the blood is considered a contributary cause. An obstructed lymph flow is also regarded as the cause. Be that as it may the immediate effect of cold upon the skin is to constrict the small blood vessels and retard the blood stream. If the exposure to cold is severe the minute vase-motor nerve terminals, which control the constriction and dilatation of the capillaries, are destroyed and this function is lost. In the winter season there is a congestion and stasis of the affected area as the result of this loss of vase-motor control. Following inflammatory reaction a fibrosis rapidly takes place which further limits the normal blood flow.

Treatment.

Early cases of chilblain are best treated by the Oudin or Tesla high frequency current applied with a non-vacuum surface condenser electrode. Sufficient current should be switched on to throw a spark one-eighth of an inch long and the electrode should be slowly moved over the affected area and surrounding skin for 5 minutes. The spark gap should then be opened until a spark one-quarter of an inch or more is ,produced and while the electrode is held away from the skin a shower of sparks should be directed upon the part for 30 seconds. This treatment should be repeated daily for three or four days, with alternate hot and cold foot-baths prescribed as home treatment. Early cases, in which pain is acute, may be treated by actinic rays. The air-cooled lamp may be used at a target skin distance of 8 to 10 inches for 2 to 5 minutes daily over a period of three or four days; or the water-cooled lamp may be used at a distance of one inch from ½ to 2 minutes for two or three treatments. The mercury vapor quartz electrode (described under the treatment of ulcers) has given satisfactory results in this condition when used at a distance of one-quarter of an inch for 5 to 10 minutes.

Cases of chilblain or frost-bite of the more severe type, or

chronic cases which occur at regular intervals during the winter season, should be treated by diathermia. These cases are invariably fibrositic and conversive heat is required to produce arterial hyperemia and soften the fibrous tissue. Treatment of these cases is best accomplished by use of the water bath and cuff electrode above the seat of disease. If the toes are the affected parts they should be inclined in a salt solution in which one terminal from the d'Arsonval apparatus is placed, while the other terminal is clipped to a cuff electrode placed about the calf of the leg. If the chilblain is situated upon the back of the heel it should be dropped into a water bath and a plate electrode placed upon the back of the leg about four inches above the congested area.

In old cases of pernio negative galvanism is frequently of distinct value. The negative pole should be placed over the affected area and the larger indifferent, or positive electrode, higher up the leg or foot. A low milliamperage, 2 to 5 ma. should be used for 10 or 15 minutes. Where diathermia is not available visible light followed by gentle massage and alternate hot and cold foot-baths may be used in treating these conditions.

Ulcers.

An ulcer is a progressive loss of tissue in skin or mucous membrane which has previously been the seat of inflammatory changes. The tissue is lost cell by cell, not in visible portions and is usually attended by more or less suppuration. The types of ulcer most commonly found upon the foot are known as callous, perforating, varicose, syphilitic, tuberculous and diabetic.

Callous or *indolent* ulcers occur most frequently upon the leg, but may be found upon the foot or ankle. They follow traumatism or infection and occur at the site of the injury or infection. The lesion is at a deeper level than the surrounding skin, with an indurated base and surroundings, a pale yellow surface devoid of granulations and secreting a thin discharge.

Perforating ulcer develops where pressure and irritation are greatest. This is usually upon the sole of the foot over the metatarsal heads, especially the first and fifth bones; upon the ball of

the great toe; upon the dorsal surface of hammer toes and upon the heel. But one foot is affected as a rule. This ulcer is generally found in connection with diseases of the nervous or circulatory system with traumatism or the existence of a corn or callus acting as the exciting cause. They are irregularly circular in shape, deeply punched out of the callus tissue, the edges of which are thick, hard and over-hand the wound. The sloughing ulcer secretes a small amount of offensive, watery pus and extends deeply into the tissues, even to the point of attacking the bone. These lesions are very stubborn, chronic and are without pain or tenderness.

Varicose ulcer is associated with varicose veins or follows a

Fig. 52
Mercury-Vapor Quartz High Frequency Electrode.

phlebitis. The exciting cause is usually a slight injury in a limb whose vitality is impaired by the varicose veins. These ulcers are usually found upon the lower third of the leg, at times upon the foot in front of and below the inner and outer malleolus. Their edges are thick, everted and swollen, while the base of the ulcer consists of large granulations which bleed easily. The discharge is thin, serous and blood stained. Several ulcers may be present upon one limb, varying in size, with a tendency to run together. A brownish pigmentation of the surrounding skin is quite the rule.

Syphilitic ulcer is recognized by the history of syphilis, verified by the Wasserman test and the fact that they are generally found upon the upper third of the leg. These ulcers are cleanly punched out with a deep, copper colored, sloughing base and thin, red edges.

Tuberculous ulcer is evidenced by the history of previous glandular, bone or lung disease. The edges are thin, irregular and the floor covered with soft, pale granulations. Symptoms of tubercular

involvement of the bone and other nearby structures accompany the ulceration.

Diabetic ulcer may be considered as a form of perforating ulcer due to a disturbance of general nutrition with lowered resisting powers of the tissues. The tendency is toward gangrene, either dry or moist, with extension to surrounding tissues.

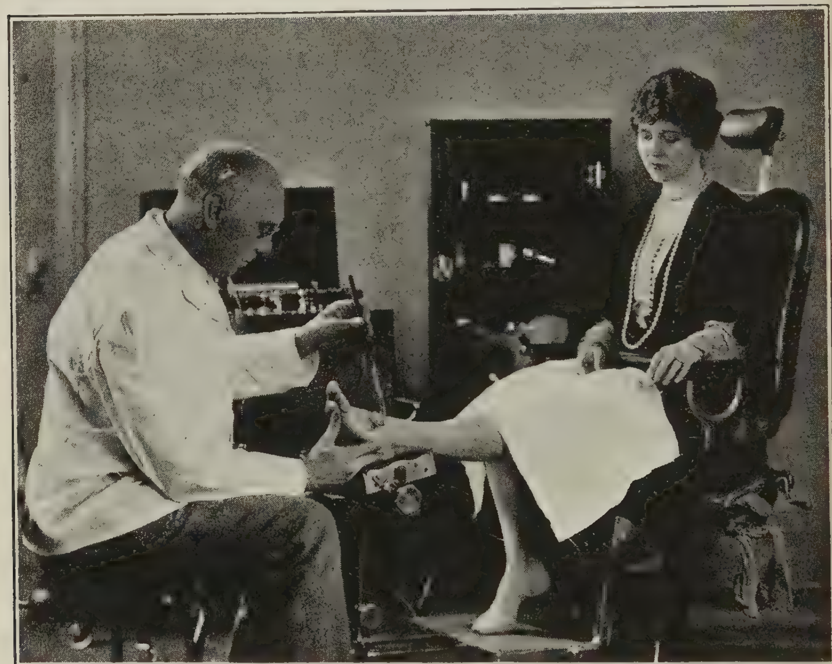

Fig. 52A

Method of Treating an Ulcer by Ultra-Violet Ray Emanations Obtained by the Use of the Mercury Quartz High Frequency Electrode Connected to the Oudin or Tesla Current. The Electrode Is Being Held About One-Half Inch from the Skin. Ulcerated Corns, Sluggish Wounds, Paronychia, Varicose Veins, Chilblains and Chronic or Fissured Skin Lesions Offer an Attractive Field for the Use of This Modality.

Treatment.

Physio-therapy offers a wide range of modalities for the treatment of ulcer. Convective heat may be secured by the use of superheated air or radiant light and heat, while diathermia furnishes conversive heat. The therapeutic action of visible light may be utilized as well as the invisible actinic rays. The galvanic current

may be used for its definite chemical action upon the diseased tissues as well as its ionizing properties.

The ultra-violet ray is the best modality in the general treatment of all forms of ulcers. An air-cooled lamp is to be used in preference to the water-cooled, except where there is much infection, in which case the latter would be indicated. In using the air-cooled lamp a stimulative reaction should be secured by an application of 4 or 5 minutes at 30 inches, gradually reducing the distance to 18 inches and the time to 15 or 20 minutes. In cases exhibiting considerable infection the bactericidal action of the short actinic rays are secured by exposures of one minute at a distance of one-half to two inches with the water-cooled lamp. Before giving ultra-violet treatment all crusts, secretions or medicaments previously applied must be removed from the ulcer and surrounding skin, which should be exposed to the emanations for a distance of two or three inches in all directions.

Since writing the chapter upon high frequency currents and the ultra-violet ray my attention has been called, and I have been using, the **mercury-vapor quartz high frequency electrode** in treating small skin lesions upon the foot and leg. For chiropodial use where the actinic ray is indicated in treating small, localized areas these quartz electrodes appear to be ideal. (Figure 52.)

In using the ordinary glass condenser electrode upon the Oudin or Tesla current practically no ultra-violet rays are obtained as these rays do not penetrate glass. The mercury-vapor quartz electrodes are made of transparent quartz permeable to actinic rays precisely as the mercury quartz burner of the large lamps. A small quantity of mercury is introduced within the quartz tube and after the air is exhausted it is filled with Argon gas, which assists in the passage of the electric current and the vaporization of the mercury. After the mercury is vaporized the tube functions the same as an ordinary quartz burner and emits ultra-violet rays, as all the conditions for the production of the rays are present, namely heat, electrotonic vibration in an evacuated quartz tube and mercury. A spectograph of the quartz high frequency electrode (Figure 53)

made by the University of Lyons, France, shows that the lines are ranging from about 2350 Angström units, of the middle ultra-violet region, into the visible spectrum at about 4360 Angström units. Thus a large ultra-violet emission is secured by this tube, which is assisted by the heat generated by the high frequency effleuve.

These tubes may be used upon any Oudin or Tesla appartus as the ordinary condenser electrode. For local foot work a flat surfaced electrode about one and one-quarter inches in diameter is furnished and is the type with which I have experimented. As they are of comparatively recent introduction no special technic is available. Clinically I have been able to obtain all degrees of skin reaction at target skin distances ranging up to one and one-half inches. Periods of exposure have run from one-half to fifteen minutes. Using a current sufficient to develop a spark one-eighth of an inch long I have been able to produce a regenerative erythema in three minutes with the electrode held lightly against the skin. In using the mercury-vapor quartz electrode it should be first carefully heated over an alcohol lamp until the mercury begins to vaporize after which it should be attached to the Oudin or Tesla terminal and sufficient current switched on to produce a spark at least three-fourths of an inch long. This spark should be sprayed upon a metallic object until the tube becomes very hot and the mercury vaporizes, which is apparent by the change in the color of the visible rays emitted, green and blue becoming more prominent with a lessening of the characteristic violet color. As soon as there is considerable vaporization the current should be reduced until a spark from one-eighth to one-fourth of an inch is produced. At these distances the tube may be held over the affected area and moved slowly about if the effleuve is too sharp. As the tube cools off it may be held in contact with the skin, moving it about if the heat is still too great. At times it is necessary to reheat the tube as it cools and the intensity of the visible rays decrease. The initial treatment should not be over one minute, gradually increasing the period of exposure as the skin reaction is obtained and noted. Of course the action of this electrode is not as powerful as that of a quartz lamp but from

Fig. 53

A Spectograph of the Mercury-Vapor Quartz High Frequency Electrode.

present observation and results I believe the ultra-violet emissions obtained in this way sufficient to treat all localized skin lesions and ulcers upon the foot coming within the province of the chiropodist. Experimentation with this appliance is worth while.

Visible light, by relieving the blood and lymph stasis, is of great benefit in the treatment of ulcers. It is frequently used to precede the administration of actinic rays. In either case it should be of moderate intensity and continued for 15 minutes.

Diathermia is used to increase local blood supply and to absorb much of the inflammatory products which are interfering with local metabolism. Block-tin electrodes should be placed above and below the ulcer in such a position that the current will flow *under the surface* of the ulcer. Terminals should be clipped to opposite edges of the tin plates and should be reversed from time to time during the treatment. If the ulcerated surface is very large a cuff electrode may be used upon the calf of the leg and the foot placed in a saline water bath which constitutes the opposite electrode. In cases of varicose ulcer where there has been recent bleeding diathermia should not be used on account of its liability to cause a recurrence of the hemorrhage.

The Tesla or Oudin high frequency current applied by means of a glass condenser electrode is of benefit in the treatment of ulcers. The electrode should be held in contact and passed over the surface of the ulcer and adjacent skin for 5 minutes, using a current capable of throwing a quarter of an inch spark. This causes an active hyperemia, relieving stasis and stimulating healthy granulations. Terminate the treatment by throwing a shower of sparks over the ulcer and its margins for 30 seconds.

Positive galvanism is occasionally used in the treatment of ulcers combined with the ionization of sulphate of zinc, or other suitable medicament, in order to secure its antiphlogistic and astringent action. The positive electrode covered with several layers of gauze, saturated with a one per cent solution of zinc sulphate, is placed over the ulcer and the negative electrode upon the oppo-

site surface of the part. A current of from 3 to 5 ma. should be used for at least 15 minutes.

Ulcers or sluggish wounds which fail to respond to other methods at times are benefitted by the use of super-heated air. This should be applied daily at least an hour at a temperature of from 300° to 400° F.

Skin lesions.

Of the various skin lesions found upon the foot **Eczema,** as elsewhere, is the most common, constituting from thirty to forty per cent of the lesions. It may be acute or chronic and is characterized by burning and redness of the skin. The discoloration may range in all shades from pink to a dull purple. Most cases have itching with moisture exuding from the vessicles after they rupture. Certain cases do not show a vesicular eruption, do not weep and are known as dry eczema. Upon the feet eczema is found most frequently between the toes and upon the soles. The most common varieties are the papular, vesiculo-papular and the scaly and fissured. In the two latter types the skin is thick, indurated and dry.

Psoriasis is a chronic inflammatory disease, characterized by numerous dry, reddish, rounded and sharply defined patches, covered with pearly white or grayish white scales. It is always a dry lesion and begins as a small papule which grows peripherally with an increased thickening of the scale and a tendency to coalesce with adjacent lesions, which are most commonly found upon the extenser surface of the leg, occasionally upon the dorsum of the foot.

Ringworm (tinea) is occasionally found upon the sole of the foot as well as between the toes and about the nails. It begins as small, slightly elevated and sharply limited hyperemic spots. These spread at the edges and tend to clear up in the center, producing a clean-cut, ring-like aspect.

Pompholyx is an acute inflammatory disease of vesicular and bullous character limited to the hands and feet, usually to the plantar aspect of the foot. The lesions appear as deep seated

vesicles, pin-head to pea-size, with the surrounding skin red and swollen. As new vesicles appear the older ones become milky and are absorbed, or they may increase in size and become purulent. The lesions are disposed to coalesce and form blebs which break and exude a sero-purulent exudate.

Lichen Planus is an inflammatory cutaneous disease exhibiting small, flattened papules with shiny tops and a violaceous color. The top of the papule often contains a depression and the base is irregular in outline. Upon the lower extremity this lesion is usually found upon the lower part of the leg and the outer aspect of the foot, the sole of the foot seldom being involved. This is a persistent disease of slow development, spreading by the coalesence of the papules which form dry, thick, discolored patches. Itching is marked.

In treating the various skin lesions the ultra-violet ray is of undoubted value, either used alone or combined with x-ray emanations or visible light.

In acute conditions with weeping, the more sedative rays should be used, while the chronic eczemas found upon the foot, with thickened, indurated, fissured skin are best treated by the water-cooled lamp at a distance of one inch from one to five minutes. The idea is to blister the skin and obtain a complete peeling of the epidermis. The air-cooled lamp used at a target skin distance of twelve inches for three to ten minutes will also accomplish the same result. In treating skin diseases the general rule is that the more chronically inflammed the area the shorter the wave length and the greater the skin reaction to be produced. In treating skin lesions all ointments and powders must be removed as well as crusts and exudates. When skin folds exist they should be smoothed out so that all parts of the surface are equidistant from the burner. Period of exposure and frequency of after treatment should be governed by the individual skin reaction and condition of the case.

Onychia and Paronychia.

Definition.

Onychia is an inflammation of the matrix or nail-bed.

Paronychia is an inflammatory condition of the tissues surrounding the nail. It may give rise to an onychia or be associated with it.

Etiology.

Onychia may be due to traumatism, which causes thickening of the nail, pressure and consequent inflammation, or more frequently it is due to infection of the nail matrix with pyogenic organisms.

Paronychia may also be due to traumatism, but more frequently it is caused by bacterial infection as the result of cutting or treating the nails with unclean instruments, or the infection of a suppurating ingrown toenail spreading to the surrounding soft parts.

Syphilis, tuberculosis, eczema and ringworm are factors in a certain percentage of these inflammatory nail cases.

Pathology.

The pathology of onychia is that of inflammation followed by the formation of pus and degeneration of the tissues under the nail, a separation of the nail from the matrix and breaking down of the tissue about the edges of the nail. The nail falls off and if the destruction of the matrix has been complete it does not return. Where a portion of the matrix is uninvolved new nail will grow and this growth is usually distorted, conforming to the shape and location of the fragment of matrix from which it originates. Periostitis of the distal phalanx of the toe may follow deep destruction of the nail bed.

The pathology of paronychia is much the same as that of onychia, the tissues surrounding the nail becoming infected, with all the signs of inflammation. Pus may or may not develop. If the condition persists the soft parts are loosened from the nail, thickened and swollen. Involvement of the matrix is common.

Treatment.

Surgical treatment is first indicated. If the nail is separated from the matrix it should be removed and the affected area drained. Antiseptic and astringent medication should be applied to combat the inflammatory and infectious process. Following surgical intervention the best treatment is the use of the actinic rays from the

water-cooled lamp given for about one minute daily at a distance of one-half inch. After a few days this may be replaced by the air-cooled lamp at a distance of 36 to 40 inches for its tonic effect. The use of the quartz mercury-vapor high frequency electrode should be of value in treating these cases. Visible light hastens the reparative process and next to the actinic rays is the best treatment in the later stages of these diseases. In early cases of paronychia a mild Oudin current will relieve the inflammation and pain.

Ingrown toenail.

After the offending portion of the nail is removed and the soft parts treated by appropriate means the healing process will be stimulated by the use of the ultra-violet ray or visible light as indicated in onychia and paronychia. Excess granulation tissue is best destroyed by the dessication method with the Oudin high frequency current. A current sufficient to produce a spark one-sixteenth to one-quarter inch should be used and the entire granulated area should be gone over until it is dried and devitalized.

In the radical operation for the removal of a toenail it is frequently difficult to remove all of the matrix, and it is understood that the matrix must be removed in its entirety or the nail, or a portion of the nail, will return. In such cases destruction of the matrix may be made certain by monopolar dessication with the Oudin current. A current of sufficient strength to throw a spark one-sixteenth of an inch will be required and its application continued until the entire surface of the nail matrix is covered and destroyed.

Corns.

Inflammed, infected or ulcerated corns are greatly benefited by physio-therapeutic measures following the regular operative procedures. As the result of pressure and the existence of a foreign body i. e. the corn, the tissues surrounding the excrescence become inflammed, congested and swollen. Such conditions call for the Tesla or Oudin high frequency currents, applied by means of the glass condenser electrodes, in an effort to reduce the stasis and inflammation, relieve the pressure and consequently the pain. The

current strength should be low, one-quarter of an inch spark, and the electrode moved lightly over the affected area and adjacent tissues for two or three minutes. The action of this current and dosage is sedative and antiphlogistic. Where the corn is situated upon the fifth toe it is well to apply the current over the entire outer side of the foot, following the course of the external saphenous nerve which supplies the fifth toe.

While the same method may be used in treating infected corns yet the ultra-violet ray is a more potent agent in relieving inflammation as well as hastening resolution in view of its definite bactericidal action. The cellulitis frequently produced by such an infection is best treated by visible light and local hot packs of Borrow's or sulphate of magnesia solution.

Ulcerated corns may be treated with a low Oudin or Tesla current followed by an effleuve of sparks for 10 or 15 seconds for their stimulative effect. The electrode should be held about one-quarter of an inch from the surface and current sufficient to throw a spark of this length used. The ultra-violet ray is especially indicated in these cases as in all ulcerated conditions. The water-cooled lamp should be used at first, followed by tonic rays from the air-cooled lamp. The actinic rays emitted by the quartz mercury-vapor high frequency electrode have been very successful in treating these lesions. A current sufficient to produce a spark one-quarter of an inch long should be used after the tube has been well heated and vaporization of the mercury obtained by a higher voltage. As the tube cools off it may be applied in contact with the ulcer. Visible light is also of undoubted value in treating sluggish ulcerations and wounds.

Soft corns existing between the toes or upon the toe web are best treated by the Oudin or Tesla current with a flattened, rod-shaped glass electrode as used in nose and throat work. For ordinary surface treatment about the toes a flat, circular electrode, about one and one-quarter inches in diameter is the most suitable.

The group of nerve filaments surrounded by enlarged papillae which rise to the surface in a certain type of corns known as *neuro-*

fibrous may be frequently removed by the dessication method, thus converting the intensely sensitive neuro-fibrous corn into an ordinary hard one. After thoroughly removing the excrescence the Oudin current (one-sixteenth inch spark) should be used directly over the loop of nerve endings for a few seconds until the minute area is completely dessicated. While the procedure is a bit painful yet it is of short duration and most patients are able to bear the discomfort. It is hardly necessary to inject a local anaesthetic in these cases, but where it is necessary to lessen sensation the *compression* method may be used. This consists in slightly moistening the area from which the neuro-fibrous corn has been thoroughly removed, placing a large crystal of cocaine hydrochlorate directly over the nerve filaments and making firm and deep pressure upon the cocaine crystal with the ball of the thumb. After a few minutes of pressure the part will generally be sufficiently anaesthetized to permit a short period of dessication.

Vascular corns should be treated by dessication or tissue coagulation, preferably the former, as directed under the subject of papilloma and verruca.

CLOSSARY

A.

A°. Symbol for Angström unit.

accessory sinuses. Hollow spaces in the bones of the face and head communicating with the nose.

acidosis. An excess of acid products within the body; when the condition gives rise to morbid symptoms the condition is called acid intoxication.

acquired. Referring to a disease or deformity contracted after birth.

actinotherapy. The use of all chemical light wave lengths, principally between 6000 and 2000 Angström units.

active. Efficient; producing effect and motion; not passive.

active motion. Motion produced through efforts of muscles controlling the part that is being moved.

adolesence. Youth; the period between puberty and adult life.

ampere. An electrical unit of volume of flow. See milliampere.

amperage. The strength of an electrical current.

anaemia. A condition in which the blood is reduced in amount or is deficient in red-blood cells or in hemoglobin.

anaesthesia. Loss or sensation.

anaesthetic. A drug which produces local or general anaesthesia.

analgesia. Loss of sensibility to pain.

Angström unit (A°). A unit of wave length measurement used in measuring light waves. It is 1/10, 000,000 of a millimeter in length.

anion. Having an excess of negative charge of electricity and moving toward the positive pole.

ankle valgus. A degree of weak-foot in which the prominence of the inner ankle is marked.

ankylosis. Stiffening or fixation of a joint.

anode. Positive pole.

anterior. In front.

antiphlogistic. Preventing or relieving inflammation.

areolar tissue. Loose connective tissue containing many interspaces.

armamentarium. In medicine all the means, drugs, instruments, etc. at the disposal of the practitioner to fit him for the practice of his profession.

arterio-sclerosis. Hardening of the arteries.

articular. Relating to a joint.

articulation. A joint as formed by meeting of the bones.

asepsis. Absence of pathogenic bacteria.

atom. A central or nuclear group of protons and electrons surrounded by numbers of electrons. The number of positive and negative charges varies with the character of the atom but is always the same for an atom of a given substance. The electrons not included in the nuclear group are called planetary electrons. If the sum total of all the positive and negative charges just balance, then it is a normal atom, but if not it is called an ion. (Sampson).

atony. Lack of tone or tension.

atrophy. Wasting of tissue.

auto-infection. Infection by germs or toxins produced within the body.

auto-intoxication. Self-poisoning; the result of the absorption of waste products of metabolism or the products of decomposition within the intestines.

axis. An imaginary line about which a body is arranged or revolves.

B.

bacillus, plural bacilli. A rod-shaped bacterium.

bacterium. A unicellar microorganism. Plural, bacteria.

bactericidal. Causing the death of bacteria.

benign. Not endangering health or life. Innocent.

bipolar. Use of two poles in giving treatments.

bursitis. Inflammation of a bursa.

C.

C. Symbol for Centigrade temperature.

calcaneum. Os calcis.

calcareous. Chalky.

cardinal. Principal; chief.

caries. Molecular death of bone. A gradual breaking down, generally with the formation of pus.

carious. Relating to or affected with caries.

cathode. Negative pole.

cations. Ions having an excess of positive charge and moving toward the negative pole.

cell. A minute structure, the living, active basis of all animal and plant organization; composed of a mass of protoplasm containing a nucleus.

centigrade scale. A thermometer scale, generally used by scientists, in which there are 100 degrees between the freezing and boiling point of water. Freezing point O; boiling point 100. See Fahrenheit scale.

cerebrum. The principal portion of the brain.

cerebral. Relating to the brain.

chemical wave lengths. See light rays.

choke coil. A device using the inductive properties of the alternating current for limiting or controlling the amount of current entering an appliance. An automatic magnetic rheostat.

circuit. To go round. See electrical circuit.

claudation. Limping.

claw-foot. Shaffer's foot

clonic. Alternating contraction and relaxation of muscles.

closed circuit. A circuit through which current is passing or would pass.

club-foot. Talipes.

coalesce. To grow together, to unite.

colon. The lower division of the large intestine.

concussive. Imparting a shake, shock or jar.

condenser. A device for the accumulation of electricity, as a Leyden jar.

congenital. Existing at birth.

connective tissue. The general supporting or uniting tissue of the body. Fibrous tissue.

contra-indicated. Not to be used.

contour. Outline of an object.

coordination. Muscular cooperation.

counter-irritation. An agent which causes irritation or a mild inflammation of the skin with the object of relieving a deep-seated inflammatory process.

crepitus. Crepitation; grating; crackling; the rubbing sensation experienced when hair is rubbed between the fingers or where the broken ends of an object are rubbed against one another. The creaking of an inflammed tendon sheath.

D.

degeneration. Sinking from a higher to a lower level of type. A retrogressive pathological change in cells or tissue in which the functioning power is lost or reduced.

dermatitis. Inflammation of the skin.

distal. Farthest from the body or median line.

dorsal. Referring to the upper or posterior surface of a part.

dorsi-flexion, dorsal flexion. Flexion toward the dorsum; flexion of the foot upon the leg.

dorsum of foot. Upper surface of foot. Instep.

drop-foot. See talipes equinus.

E.

ecchymosis. A purplish patch caused by extravasation of blood into the tissues.

edema. See oedema.

effusion. The escape of a fluid from the blood vessels or lymphatics into the tissues or cavity of the body.

effleurage. A stroking movement used in massage.

effleuve. The fine spray from a vacuum tube or other electrode, too fine to be termed a spark.

electrical circuit. The path traversed by an electrical current from its source through intervening objects and back to its source. An electrical circle or cycle.

electrode. One of the two poles of an electrical current applied for the purpose of treatment.

electrolyte. A solution which will conduct electricity.

electrolysis. The breaking up of a compound substance by electricity.

electron. A minute charge of negative electricity, the smallest that is known to exist.

electro-motive force (E.M.F.) A synonym for voltage.

embolus. A plug or clot occluding a blood vessel.

embolism. Obstruction or occlusion of a vessel by a *transported* plug of foreign material or blood clot.

endarteritis. Inflammation of the inner coat of an artery.

epidermis. Outer layer of the skin.

equilibrium. The condition of being evenly balanced. Body equilibrium, the condition of maintaining an erect posture.

equinus, talipes. Extension of the foot; drop-foot. See talipes.

erythema. Redness of the skin.

etiology. Cause of disease.

eversion of foot. Elevation of outer border.

extension of foot. Movement of foot away from leg. Plantar flexion.

exostosis. A bony over-growth from the surface of a bone.

exudate. A liquid composed of elements from the blood discharged through the skin or into a cavity of the body.

F.

F. Symbol for Fahrenheit temperature.

facet. A small, smooth area on a bone; the articulating surface of a bone.

Fahrenheit scale. The degree markings on the Fahrenheit thermometer, in which the freezing point of water is 32 degrees and the boiling point 212 degrees. See centigrade scale.

facia. A sheet of fibrous tissue enveloping the body beneath the skin, also enclosing the muscles and groups of muscles and separating their several layers or groups.

fibrin. The active agent in the coagulation of blood.

fibrosis. The pathalogical formation of fibrous tissue, especially marked after inflammatory conditions.

fibrous tissue. Connective tissue.

fistula. An abnormal passage or opening leading from an abscess cavity, or hollow organ, to the surface.

flaccid. Relaxed, flabby.

flexion of foot. Movement of foot toward leg. Dorsi-flexion.

fluctuation. A wave-like motion felt on palpating a cavity or tissue containing fluid.

focal infection. An infectious process with its origin, or focus, at a point remote from the affected area.

fulcrum. A prop or support on which a lever turns.

G.

gangrene. Death of tissue in visible portions; a form of necrosis combined with putrefaction; mortification. Gangrene may be moist or dry and is caused by traumatism, general causes resulting in diminished blood supply to the part, or to infective organisms.

gonococcus, plural gonococci. The specific organism causing gonorrhoea.

granulation tissue. Minute, rounded, fleshy projections on the surface of a wound in the process of healing.

H.

hallux. The great toe.

hallux flexus. Hammer-toe of great toe.

hallux rigidus. Stiffness of great toe joint.

hallux valgus. Outward deviation of great toe.

hallux varus. Inward deviation of great toe.

heliotherapy. The use of all wave lengths of the sun.

hemiplegia. Paralysis of one side of the body and of the opposite side of the face.

hemostatic. Arresting the flow of blood within the vessels.

high frequency electric current. A current having a frequency of interruption or change of direction sufficiently high that tetanic contractions are not set up when it is passed through living contractile tissues.

hump-foot. Foot having a "hump" upon the dorsum at the junction of the first metatarsal and internal cuneiform bone.

hyperemia. In increased amount of blood in a part.

hypertrophy. Overgrowth; general increase in bulk of a part or organ, not due to tumor formation.

I.

immobolize. To render fixed, or incapable of moving.

incoordination. Lack of harmonious action.

indifferent electrode. The electrode not used over the affected area; in contradistinction to the active electrode used over the area treated.

induction. The generation of electricity within a body by the influence of another electrified body.

induration. The process of hardening.

infective. Relating to an infection, infectious.

inflammation. A morbid change or series of reactions produced in the tissues by injury or infection. The phenomena of inflammation are mainly redness, heat, pain, swelling and loss of function.

infra-red rays. See light rays.

inhibit. To restrain, prevent or retard.

in series. A device is in series in the circuit when all the current reaching the patient must go through it.

inoculate. To introduce the virus of a disease within the tissues.

interosseous. Between bones.

inversion of foot. Elevation of inner border.

invisible rays. See light rays.

ionization. The breaking up of acids, bases and salts in watery solutions.

ion. The word means to go or to travel. An ion is a group of atoms or parts of molecules carrying a charge of electricity.

irradiation. Illumination; to emit light rays.

ischemia. Local anaemia.

K.

kilowatt. 1000 watts.

Koehlers disease of the scaphoid. A disease of the scaphoid first discovered by Koehler. Isolated scaphoid disease.

kyphosis. Backward curvature of the spine. Hump-back.

L.

lateral. On the side; outer.

lead palsy. Paralysis of muscles due to poisoning by lead.

lesion. A pathalogic change in tissue.

leucocyte. A white blood corpuscle.

lever. One of the mechanical powers, being a bar used to exert pressure, or sustain weight, at one point of its length, by receiving a force or power at another, and turning on a fulcrum, or fixed point.

ligaments. Bands of fibrous connective tissue.

light rays, light waves. Light rays are visible and invisible. Visible or "white light" is made up of the seven prismatic colors which constitute the solar spectrum, namely: red, orange, yellow, green, blue, indigo and violet. The invisible light rays are the ultra-violet, actinic or cold rays which lie beyond the violet and have chemical properties, and the infra-red or heat producing rays which extend below the visible red. Sunlight contains all the visible rays and many of the invisible. The term *radiant light* is a misnomer, in-as-much as it includes all light rays, visible and invisible, while as a matter of fact the visible light used in

physio-therapy comprises only the light rays of the spectrum visible to the human eye.

litmus paper. Paper stained with a coloring matter known as litmus, which is reddened by acids and turned blue by alkalies.

locomotor ataxia, tabes dorsalis. A chronic, progressive sclerosis of the posterior columns of the spinal cord.

longitudinal. Running lengthwise; in the direction of the long axis of a body.

lordosis. Anterior curvature of the spine.

low frequency. A current whose frequency is such that its passage through muscular tissue is attended by tetanic contraction.

lymph. A clear yellowish fluid which circulated in the lymph spaces or lymphatic vessels of the body.

lymphatic vessels. Those through which lymph circulates.

lymphangitis. Inflammation of lymphatic vessels.

lues. Syphilis.

luxation. Dislocation.

M.

μ. μ. Symbol for millimicron. A unit of wave length measurement. 1/1,000,000 of a millimeter in length.

mains or main line. The current as it comes from the street supply or from the motor generator, if one is used.

malignant. Resistant to treatment, tendency to grow worse, and, in case of a tumor, to recur after removal. Malignant tumor—a cancer.

malleolus, plural malleoli. One of the two rounded prominences on either side of the ankle joint.

mechanotherapy. Treatment of disease by mechanical means.

medial. Middle.

medio-tarsal joint. Formed by the articulation of the os calcis and astragalus behind and the cuboid and scaphoid bones in front. The mid-tarsal joint.

metabolism. The process of body waste and repair.

metatarsus. The five metatarsal bones.

metatarsus varus. A foot where the toes and metatarsus are bent inward at the tarse-metatarsal joint.

Meyers line. A line extending through the middle of the foot and great toe.

mid-tarsal joint. Medio-tarsal joint.

milliampere. 1/1000 of an ampere. The electrical unit of quantity as used in medical treatment.

milliamperemeter. Instrument for measuring milliamperage of a current.

millimeter. 1/1000 of a meter. Roughly 1/25 of an inch.

mobility. Being movable.

modality. Any mode or method of using a physical remedy in therapy.

molecule. Two or more atoms in combination.

monopolar. Use of one pole only in giving electrical treatments.

morbid. Diseased.

myalgia. Muscular pain.

myelitis. 1. Inflammation of the spinal cord. 2. Inflammation of the bone marrow, osteomyelitis.

myositis. Inflammation of muscle tissue.

N.

naevus. A congenital mark or discolored patch of the skin due to pigmentation or hyperplasia of the blood vessels.

neoplasm. A new growth; tumor.

neurasthenia. Symptoms due to exhaustion or disability of the nerve centers.

neuritis. Inflammation of nerve tissue.

neurotic. Nervous.

normal. Typical; healthy.

nucleus. The center of the functional activity of a cell.

O.

oedema. An abnormal accumulation of clear watery fluid in the lymph spaces of the tissues; dropsy, hydrops.

ohm. The unit of resistance to the passage of an electrical current.

open circuit. A circuit broken so that a current can not pass.

organism. Any living being, either animal or vegetable.

os. A bone.

oscillating. To move to and fro; to swing or vibrate.

osseous. Bony.

ossicle. A small bone.

ossification. Formation of bone.

osteophyte. A bony over-growth; exostosis.

P.

palmar. Referring to the palm of the hand.

papilloma. See verruca.

paralysis. Loss of muscular power.

paresis. Incomplete loss of muscular power, slight paralysis.

passive motion. Motion not produced by the muscles controlling the part, but by another agency or force, as the hands of the examiner.

pathogenic. Causing disease.

pathology. The branch of medical science which deals with disease in all its relations, especially with its nature and the functional and material changes caused by it.

percussion. A massage movement consisting of repeated blows or taps of varying force.

periarthritis. Inflammation of the soft parts about a joint.

periphery. The part of a body away from the center; the outer part or surface.

peripheral. Relating to or situated at the periphery.

pes. The foot.

pétrissage. A massage manipulation consisting in kneading of the muscles.

phagocyte. A cell possessing the power of ingesting bacteria, foreign bodies and other cells.

phagocytosis. The process of ingestion and digestion by the cells.

phase. One stage or alternation of an alternating current, as a negative phase, or a positive phase.

phenomenon. A symptom, an occurence of any sort, in relation to disease.

phlebitis. Inflammation of a vein.

phototherapy. The use of all the wave lengths from the sun and those artificially produced. This includes infra-red, visible and ultra-violet rays.

physics. The branch of science which deals with the phenomena of matter, with the changes that matter undergoes without losing its chemical identity.

physiological. 1. Relating to physiology. 2. Normal as opposed to pathological, noting the various vital processes.

physiology. The science which deals with living things, with the normal vital processes of animal and vegetable organisms.

plantar. Relating to sole of foot.

plantaris, talipes. A synonym for Shaffer's foot.

plantar flexion. Flexion towards sole of foot. Extension of foot on leg.

plasma. The fluid portion of the circulating blood, distinguished from the *serum* obtained after coagulation.

posterior. Behind; after.

potential. A synonym for voltage.

predisposing. Tending to render susceptible to disease.

prognosis. Forecast of the termination of a disease.

pronation. A synonym for eversion.

proton. The nuclear positive corpuscle of electricity.

protoplasm. Living matter, the substance of which animal and vegetable tissues are formed.

proximal. Nearest the trunk of the body.

pyemia. A condition where pathogenic bacteria circulate in the blood and form abscesses wherever they lodge.

pyogenic. Pus forming.

R.

rachitis, rickets. A disease of impaired nutrition and softening of the bone.

radiant light. See light rays.

radiograph. An x-ray negative.

rarefaction. Decreasing the density of a substance.

Raynaud's disease. A vase-motor neurosis, affecting fingers and toes, with paller, congestion and even gangrene.

rays. See light rays.

rectifier. A device for changing alternating to direct current.

rheostat. A fixed or variable resistence for controlling the amount of current entering the patients circuit.

reflex. A reaction; an involuntary movement in a part.

refract. To turn light rays from a direct course.

regeneration. Reproduction or repair of lost or injured parts.

rotation of feet. Movement of the foot as a unit with the leg, resulting from rotation of the leg at the hip joint.

resistance. Opposition by a body to the passage of electricity through it.

resolution. Return to normal after a pathologic process.

revulsive. A counter-irritant.

S.

sanguineous. Relating to blood.

sclerosis. Hardening due to inflammation.

scoliosis. Lateral curvature of spine.

serum. The clear, yellowish fluid separating from the blood after the coagulation of the fibrin. See fibrin.

septic. Produced by or due to putrefaction.

shunt. A device is in shunt when the current has the choice of an alternate path, either through it or around some other circuit.

sinus. A fistula or tract leading to a suppurating cavity.

skiagram. An x-ray negative.

solar spectrum. See light rays

solenoid. A coil or series of turns as wire spaced equally between turns.

spasm. An involuntary muscular contraction. Cramp.

spastic. Spasmodic; convulsive.

specific diseases. These caused by special microorganisms.

spur. A projection from a bone.

stasis. Stagnation of the blood or other fluids.

static. At rest.

static ataxia. Inability to preserve the equilibrium in standing.

subacute. A disease not acute or chronic; between.

supernumerary. Excessive number.

suppination. A synonym for inversion.

suppuration. Producing pus.

synovia. Lubricating fluid of a synovial membrane.

synovitis. Inflammation of a synovial membrane.

synovial membrane. Lining membrane of a joint.

systemic. Referring to entire body or system.

T.

talipes. Club-foot.

talipes equinus. Extension of the foot. Drop-foot.

talipes plantaris. A synonym for Shaffer's foot.

talipes valgus. Eversion of the foot, with fore-foot in abduction. Abducted foot. Pes valgus. Pronated foot.

talipes varus. Inversion of the foot with the fore-foot in abduction. Pes varus. Suppinated foot.

talus. Astragalus.

tapotement. A massage movement consisting in striking with the side of the hand or fingers.

tarsal. Relating to the tarsus.

tarsus. The seven posterior bones of the foot.

technic, technique. The manner of performance, or the details, of any operation, experiment or mechanical act.

temperature. The sensible heat of any substance.

temperature scale. See Fahrenheit.

tendon. A fibrous band connecting a muscle to its attachment.

tendo-synovitis. Inflammation of a tendon and its sheath.

tension. A synonym for voltage.

tetanus. A tonic muscular contraction, especially one induced by an electrical current.

tetanic. Relating to or marked by tetanus.

therapeutics, therapy. The practical branch of medicine dealing with the treatment of disease.

thermic. Relating to heat.

thrombosis. Formation or presence of a thrombus.

thrombus. A plug, or clot, occluding a vessel.

tonic spasm or contraction. A continuous muscular contraction, as in tetanus, opposed to *clonic* spasm.

toxemia. Blood poisoning.

toxic. 1. Poisonous. 2 Relating to a toxin.

toxins. A poisonous substance of undetermined chemical nature, elaborated during the growth of pathogenic microorganisms.

transformer. An electrical device for raising or lowering the voltage of an induction current.

trauma. A wound or injury.

traumatic. Relating to or caused by a wound or injury.

trophic. Relating to nutrition. Trophic nerves, those that govern the nutrition of the part supplied by them.

tumor. Neoplasm. Any swelling or tumefaction.

U.

ulcer. Loss of tissue on skin or mucous membrane.

ultra-violet ray. See light, rays.

unilateral. One side only.

V.

vacuum. A space from which the air has practically been removed.

valgus. See talipes.

varicose. Related to or affected with enlarged veins.

varus. See talipes.

vascular. Relating to or containing blood vessels.

vaso-constrictor nerves. Controlling constriction of blood vessels.

vaso-dilater nerves. Controlling dilitation of blood vessels.

vaso-motor nerves. Nerves controlling expansion and contraction of blood vessels.

venous. Relation to a vein or the veins

verruca. Wart, a circumscribed hypertrophy of the papillae and epidermis.

virus. 1. Centagium, the specific poison of an infectious disease. 2. Vaccine lymph.

viscera. Internal organs; especially the large abdominal organs.

visible light. See light rays.

volt. An electrical unit of pressure, driving force.

voltage. Electrical pressure; potential; electro-motive force.

W

watt. An electrical unit of quantity of flow or rate at which energy is used.

wattage. Voltage × amperage = wattage.

Wasserman test. A diagnostic blood test for syphilis.

weak-foot. A general term applied to all disabilities of the longitudinal arch, including strained foot; incipient weak-foot; simple or relaxed weak-foot; spastic weak-foot; flattened-out weak-foot or flat-foot; congenital weak-foot; paralytic weak-foot, etc.

Index to Subjects

A

B

C

D

E

F

G

H

I

K

L

M

N

Q

R

S

T

W

X

Z